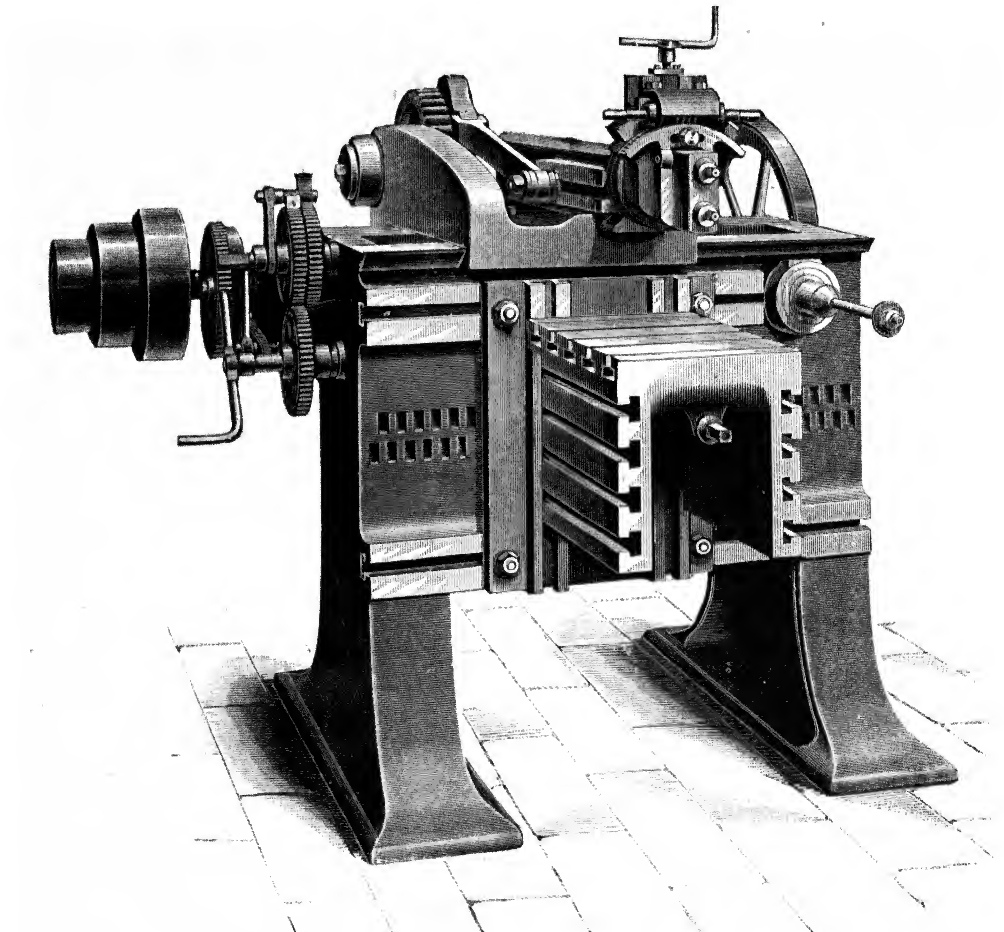
10-INCH STROKE SHAPING MACHINE.



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MACHINE DRAWING

FOR THE USE OF

ENGINEERING STUDENTS

IN

SCIENCE AND TECHNICAL SCHOOLS AND COLLEGES

BY THE LATE

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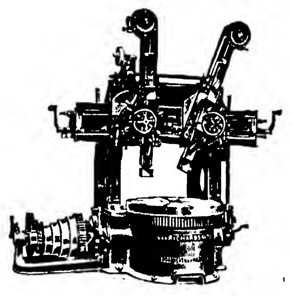

BOOK II.

MACHINE TOOLS.

NEW EDITION—REVISED

JOHN HEYWOOD LTD.

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PREFACE.

THE drawings of machine tools given in the following pages are all taken from actual machines constructed at the present time by expert engineers and tool makers.

The objection which is often made by our leading engineers and engineering journals that the drawing exercises, given to students in Technical Schools and Colleges, are of old fashioned and out of date machine details cannot therefore be urged in the case of the present volume.

The various elevations are projected one from the other, as explained in Book I. The object is supposed to stand in *front* of the vertical plane upon which it is projected, and not *behind* it.

All the drawings are fully dimensioned, and each detail whilst furnishing a drawing exercise for the student, is an example of the best device known for accomplishing the particular purpose for which it is used. The student is enabled to make a picture of a really existent machine detail, and also to learn the actual position and use of the detail in the machine. If of an inventive turn of mind he may be able to suggest some better device for effecting the same purpose.

The authors feel sure that the stimulation of the inventive faculty of the young engineer in the school, as well as in the workshop, is most desirable, his education will be sounder and more thorough. The knowledge of the exact use of a machine part is the best foundation upon which to build an improvement of it.

Calculations of the speeds of the driving and feed gears of the various machines are given, and in the Slotting and Shaping machines the varying velocities of the tool in the cutting and return strokes are shown graphically.

The student is also encouraged to make finished coloured drawings. Although this work may not be so important as the knowledge of correct construction, and the ability to make a good and accurate drawing, still it will in many cases be an incentive to the student to work out and finish in ink the various details. To copy Plates I. and XII. until neat and accurate drawings of the various details of the machines have been made, inked in and coloured, would be wasting time.

On behalf of engineering students generally, as well as on their own behalf, the authors hereby tender their warmest thanks to the undermentioned Manchester engineering firms, who have kindly furnished particulars from which the Plates have been prepared :—Messrs. Smith and Coventry Limited, Messrs. Hulse and Co. Limited, Messrs. Jno. Hetherington and Sons Limited, Messrs. P. R. Jackson and Co. Limited.

THOMAS JONES
T. GILBERT JONES

Manchester, *September*, 1898.

PREFACE TO SECOND EDITION.

In this edition twenty three new plates are added to the original book making a total of forty-eight. The additional plates, two of which are coloured, give full working details of a Boring and Turning Mill, a Horizontal Milling Machine, and a Pneumatic Hammer. The particulars from which these drawings are made were kindly furnished by the makers of the machines, Messrs. George Richards and Co. Limited, Broadheath, Messrs. Webster and Bennett, Coventry, and the Pneumatic Engineering Appliances Co. Limited, London, to whom we hereby tender our best thanks.

T. J.—T. G. J.

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T. J.—T. G. J.

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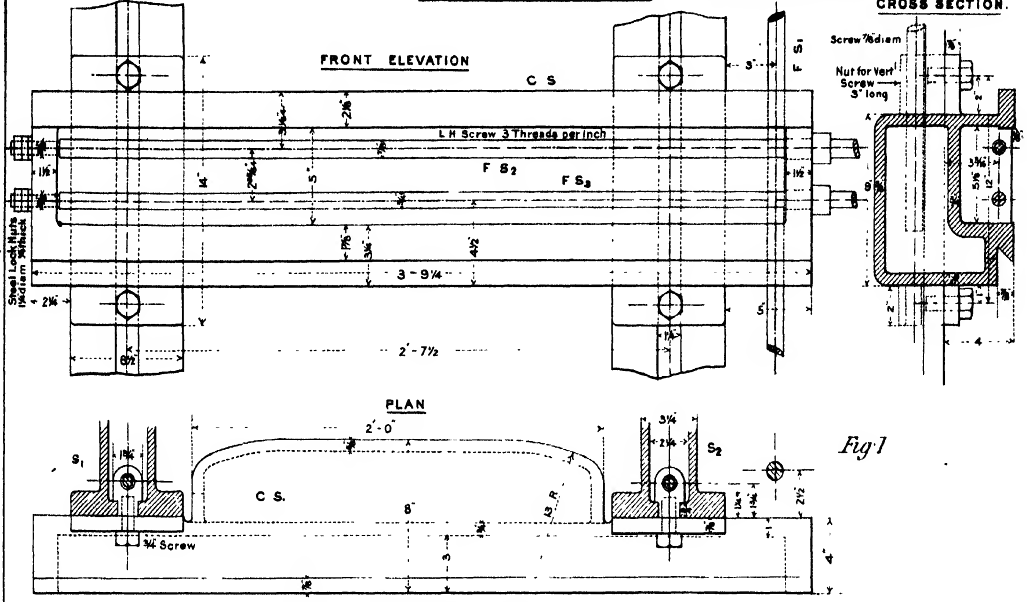
Book 2: PLATE X

PLANING MACHINE, 2'-0" × 2'-0" × 4'-0" STROKE.

DETAILS OF CROSS SLIDE. *Scale 1½" = 1 Foot.*



FEED MOTION FOR TOOL BOX. *Scale ⅓ full size.*

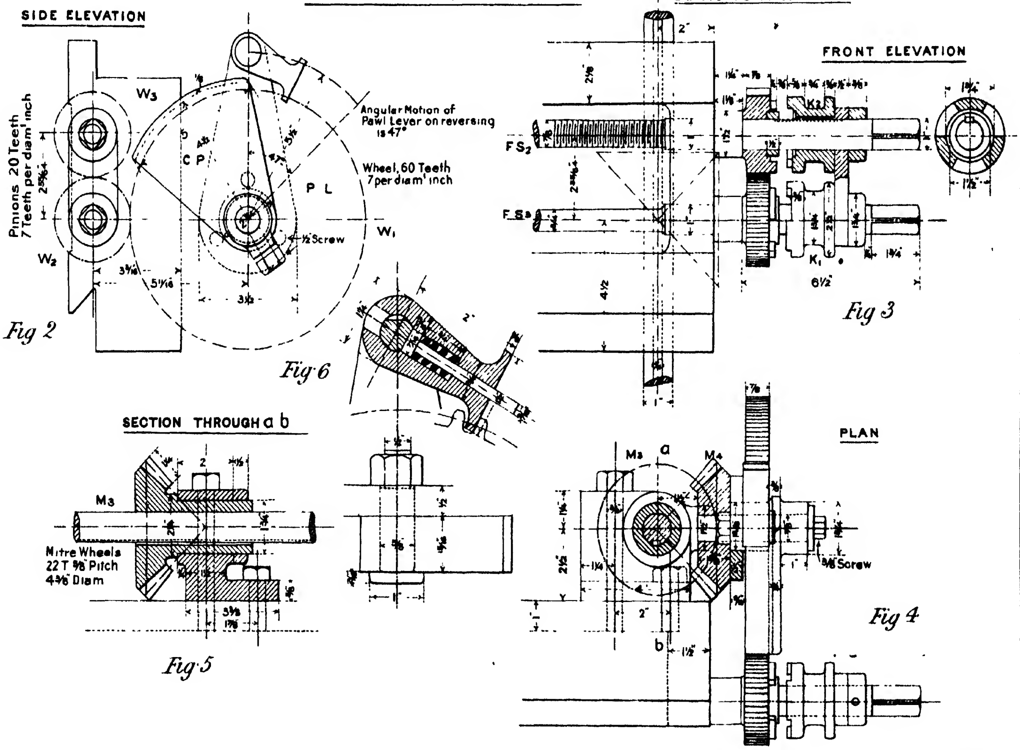


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Plate XI.—PLANING MACHINE.

DETAILS OF TOOL BOX.—The tool box is so constructed that the tool can be fed in any direction, viz., horizontally, vertically or obliquely, and also vertically when the tool is at any angle. It consists of three slides Y_1, Y_2, Y_3 and the plate V_1, the last carrying the tool holder plate V_2.

The first slide Y_1 is placed against the front of the cross slide, and is so shaped that it passes over the top edge of the cross slide and is separated from it by a steel strip of L section which moves with Y_1 and so receives the vertical wear. By adjusting the vertical and horizontal set screws against it, the slide is held against the vertical face and the bottom bevelled edge respectively of the cross slide. This same slide carries the brass nut for the horizontal feed screw FS_2, and also the double mitre wheel M_6, which, together with wheels M_5, M_7, serves to connect the shaft FS_3, with the vertical screw X of the slide Y_2.

The T groove in Y_1 being circular the bolts holding the slide Y_2 against it can be moved round, and so the tool placed in any inclined position for planing bevelled edges. Movable along the second slide by the nut and vertical screw is the slide Y_3, whose automatic motion is effected in the manner indicated in Fig. 2. Keyed to the lower end of the screw is a wrought-iron mitre wheel M_7 in gear with the double wheel M_6, whose motion is received from a third wheel M_5 carried by Y_1, and sliding along and rotating with the horizontal shaft FS_3.

When the slide Y_2 is turned into an inclined position, M_7 simply rolls round M_6, for the latter is fixed in the plate at the centre of the groove.

The two parts of the double wheel pass over a pin fitted with a feather key, and are held together by the $\frac{3}{8}''$ screw, whose head presses against the face of the right-hand piece.

The plate V_1, whose inclination relative to the slide carrying it, is limited by the curved slot in it, is provided with two parallel projections, which afford support for the bolt of the tool-holder plate V_2, and serve to prevent any side motion of it. The two steel tool-holders TH are so attached to the plate that their set screws, when tightened up, both clamp the tool in the holders and the latter in the plate.

To prevent the grinding of the tool on the work during the return stroke, the plate V_2 is hinged so that it may lift slightly. There is, sometimes, fitted on larger machines an automatic arrangement for lifting the tool clear of the work during the non-cutting stroke.

Hand feed in all directions may be given to the tool.

EXERCISES.

1.—**Back Slide Y_1 of Tool Box**. Draw the front and sectional side elevations and plan of the slide Y_1, showing its connection with the cross slide. (See Fig. 4 for details of mitre wheels.) *Scale, $\frac{3}{4}$ full size.*

2.—**Vertical Slide Y_2**. Draw the front, side, and sectional side elevations and plan, showing the screw and mitre wheel, the latter in section. *Scale, $\frac{3}{4}$ full size.*

3.—**Tool Holders, Plates V_2, V_1 and Slide Y_3**. Draw the front, side, and sectional side elevations and plan. *Scale, $\frac{3}{4}$ full size.*

4.*—**Complete Tool Box**. Draw the given views, showing in the section the wheels as in Fig. 4; add a side elevation to the left of the front elevation. *Scale, $\frac{3}{8}$ full size.*

* This Exercise is intended for Advanced Students.

PLANING MACHINE, 2′-0″ × 2′-0″ × 4′-0″ STROKE.

DETAILS OF TOOL BOX.

Scale 3=1 Foot

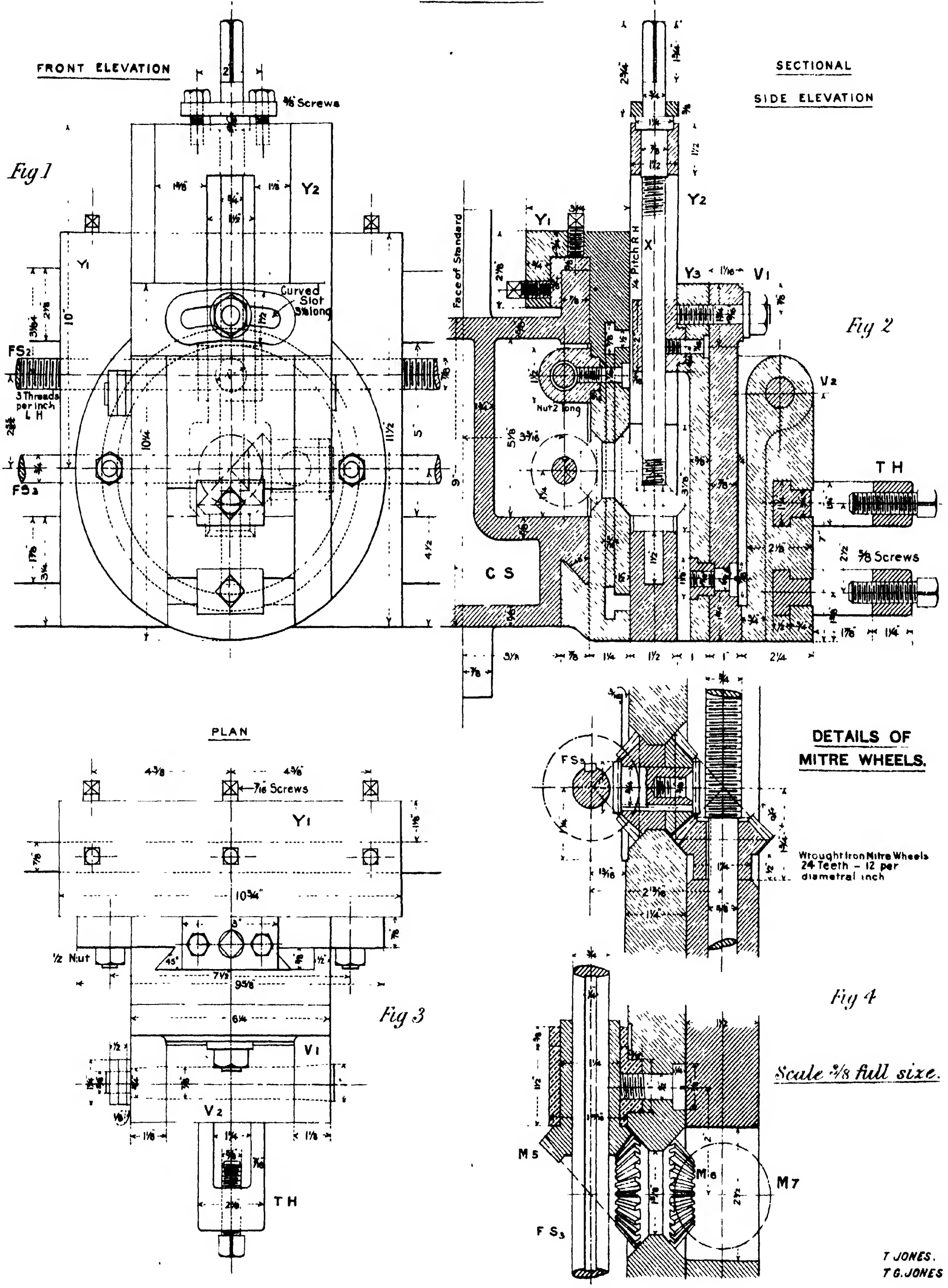


Plate XII.—SHAPING MACHINE.

GENERAL DESCRIPTION.—The shaping machine, of which detailed drawings are given on Plates XIII. to XVII., is made by Messrs. John Hetherington and Sons Ltd., Manchester. It is capable of producing horizontal, inclined or cylindrical surfaces not exceeding 10″ in length.

The counter-shaft from which the machine receives its motion is $1\frac{3}{4}''$ diameter, 3′–3″ between the bearings, and carries fast and loose pulleys 14″ diameter, $3\frac{1}{2}''$ wide, and a cone pulley of the same size as that on the driving shaft of the machine.

The bed **B**, supported on two standards, carries all the fittings of the machine. At the back the pulley shaft **DS** is supported by two arms **E, E** and connected by a pinion, sliding with the carriage, to the wheel W_2 which carries the sliding block for actuating the slotted arm **S A**.

The wrought-iron rod **K** connects the arm with the ram **R**, to which it gives a reciprocating motion across the carriage of continually varying velocity with a quick return. The ratio of the times of cutting and returning decreases with the stroke, its value being 2 to 1 when the stroke is 10″.

With the counter-shaft making 120 revolutions per minute the number of cutting strokes may be 56·2, 34·3 or 20·7 per minute. For constant maximum and mean cutting speeds the revolutions of the driving pulley must be increased as the stroke decreases.

The tool box **T B** is carried on the front end of the ram and constructed so that the tool can be fed in any direction in a vertical plane. When the back slide is vertical the feed may be effected automatically at the end of the return stroke.

The feed screw S_1 of the carriage carries on one end two ratchet wheels G_1, G_2, the former keyed and the latter turning freely on it and in gear with an equal wheel G_3 keyed on the worm shaft S_2.

The pawl lever is connected by the link L_1 to the feed lever whose end fits in an eccentric groove on the wheel W_4 in gear with W_3 on the pulley shaft. With a pawl gearing with G_1 the carriage is fed across the bed by an amount which may be varied from 18·4 to 110 strokes per inch of feed according to the position of the link L_1.

Pieces with cylindrical surfaces to be tooled are held on the circular motion mandril by conical bushes, and turned slightly with it at the end of each return stroke; the mandril carries a worm wheel in gear with a worm on the shaft S_2.

For the circular feed the pawl above G_2 is turned over, and so the forward intermittent motion of the lever is transmitted to G_3 on the end of the shaft.

The connections of the table **T** to the slide **L** and the latter to the bed are such that the table can be moved both vertically and horizontally. The former adjustment is effected by turning the horizontal screw S_3, and the latter by means of a bar used in the pinching rack **P R**.

The stay **X**, bolted to the side of the table, is placed under the outer conical bush on the mandril to steady the work during cutting.

EXERCISE.

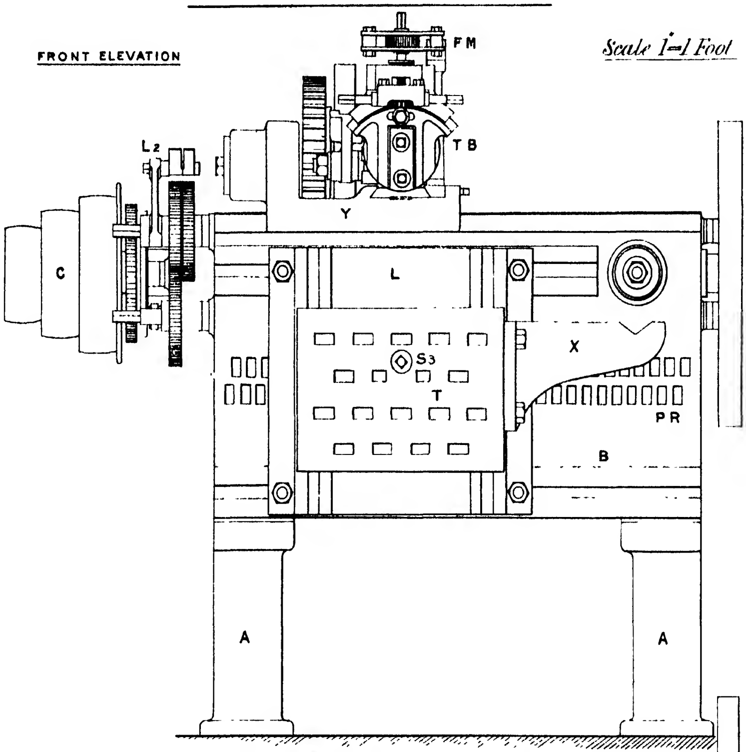
1.*—**Complete Machine.** Draw the two given views to a *Scale of $\frac{1}{8}$ full size.*

* This Exercise is intended for Advanced Students.

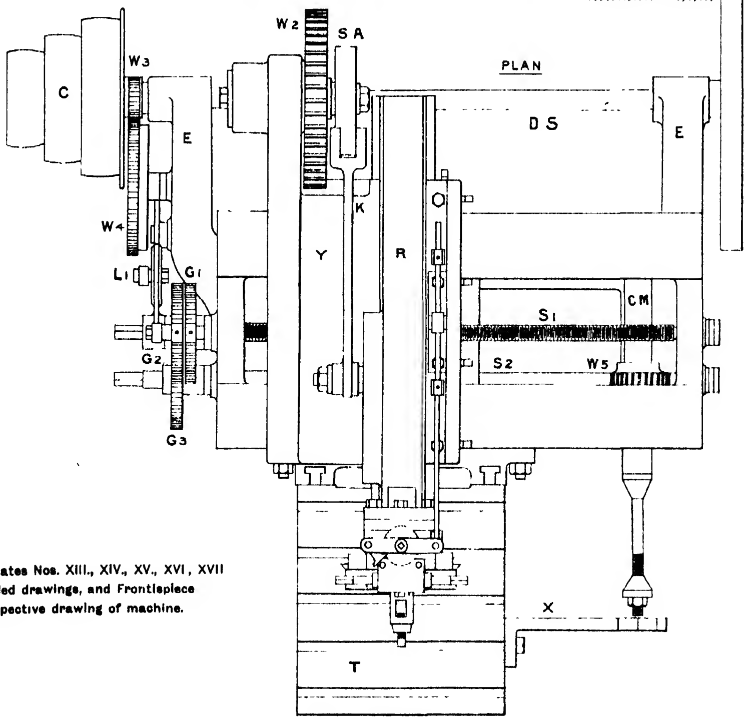
10" STROKE SHAPING MACHINE.

FRONT ELEVATION

Scale 1"=1 Foot



PLAN



NOTE.—See Plates Nos. XIII., XIV., XV., XVI, XVII for detailed drawings, and Frontispiece for perspective drawing of machine.

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Plate XIII.—SHAPING MACHINE.

DETAILS OF BED.—The machine bed is of box form, $3\frac{1}{2}'$ long × 2′ high × 1′ 3″ wide, and has cast with it two horizontal arms **E**, **E** to support the driving shaft **D S**. They are of ⊓ section, and the one at the pulley end of the shaft carries the feed wheel and lever.

The top face of the bed consists of two parallel strips $5\frac{1}{4}''$ wide, with their outer edges bevelled to an angle of 50°. At each end the bed is secured to a stand **A** (Fig. 4) by two $\frac{7}{8}''$ bolts. It will be noticed that the centre line of the stand does not coincide with that of the bed, and that the bolt holes on the top of the stand are not symmetrically placed.

Across the bed is a central web $\frac{7}{8}''$ thick with top and bottom flanges 3″ wide, the former one shaped to admit of the passage of the brass nut for the feed screw S_1.

The table slide is supported by four bolts held in two horizontal **T** slots, and moved along the bed by means of a lever whose end is placed successively in the semi-circular holes of the pinching rack **P R**.

Passing from one end to the other are the horizontal feed screw S_1 and the worm shaft S_2. Each turns in supports cast on the bed and is held endways by a shoulder at one end and circular lock nuts at the other. The wrought-iron worm, of which no drawing is given, used to transmit the intermittent motion of the shaft to the circular motion mandril, is keyed tightly on the shaft directly below the wheel.

To support the mandril, bosses are cast on the two sides of the bed, the one on the front being fitted with a conical cast-iron bush not shown in the drawing.

EXERCISES.

1.—**Standard A**. Draw and complete the front and side elevations as given in Fig. 4, and add a plan. *Scale, $\frac{1}{3}$ full size.*

2.—**Machine Bed**. Draw the three given views, and add—projected from the plan—a cross section to the left of the central web. *Scale $\frac{3}{16}$ full size.*

10" STROKE SHAPING MACHINE.

DETAILS OF BED.

FRONT ELEVATION

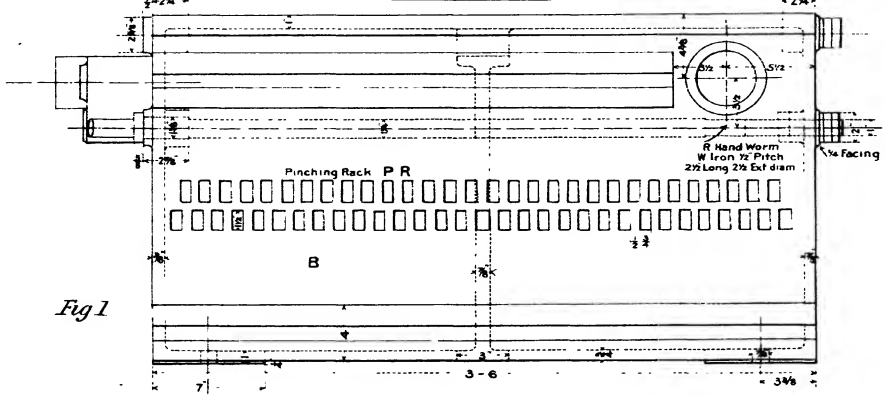

Fig 1

END ELEVATION

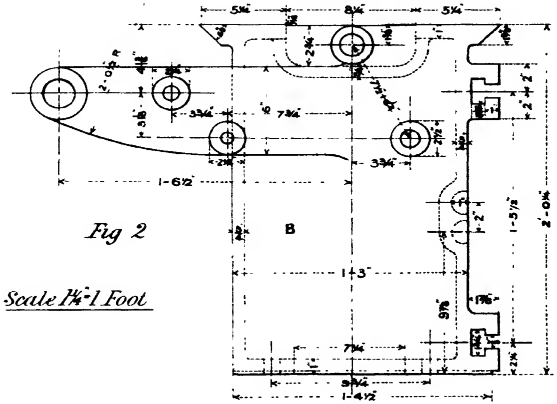

Fig 2

Scale 1¼"=1 Foot

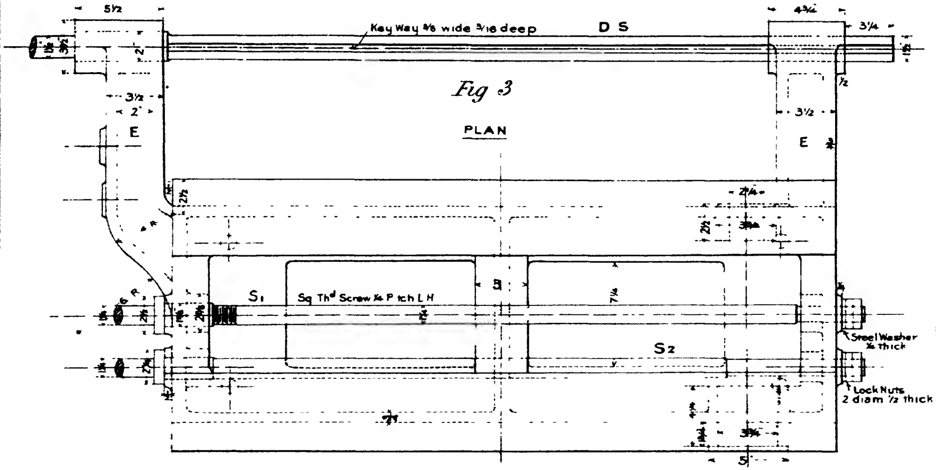

Fig 3

PLAN

STAND FOR BED.

Scale 1¼"=1 Foot

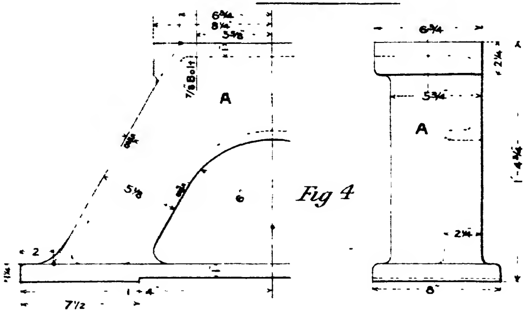

Fig 4

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Plate XIV.—SHAPING MACHINE.

DETAILS OF TABLE AND SLIDE.—The cast-iron table T, carrying the piece to be shaped, is bolted to the slide L by four $\frac{7}{8}''$ bolts held in vertical T slots. The slide L is itself secured to the front of the bed by four bolts. These connections enable the table to be moved both vertically and horizontally. For the vertical adjustment the four nuts on the bolts in the vertical slots are slackened and motion given to the screw S_4 by turning the horizontal shaft S_3, which is connected with it by the mitre wheels M_1, M_2. The brass nut for the screw is fixed to the plate L as shown in the sectional elevation (Fig. 1). The screw is held endways by a $\frac{3}{16}''$ pin passing through the table and fitting in a semi-circular groove on the end of the screw. For one revolution of the handle fixed on the square end of the shaft S_3 the table will be moved vertically through $\frac{1}{4}''$—the pitch of the screw.

To relieve the bolts from cross strain there are, on the vertical faces of the table and slide, parallel projections $\frac{7}{8}''$ wide × $\frac{1}{4}''$ thick fitting into the slots.

The table is provided on the top with T slots, and on the sides and front with rectangular bolt holes $1\frac{3}{4}''$ × $\frac{13}{16}''$ to hold $\frac{3}{4}''$ clamping bolts. In the latter particular the table shown on this plate differs from that on the perspective drawing.

Fig. 5 shows a sectional plan of the circular motion mandril. It consists of a cast-iron sleeve and a central steel spindle. The former has a conical end which turns in a cast-iron bush fixed in the front boss on the bed, and is held endways by two wrought-iron circular lock nuts screwed on the small end at the back of the machine. The portion of the spindle beyond the support is turned down to $\frac{3}{4}''$ diameter, screwed, and provided with two cone bushes, one capable of adjustment. The spindle may be turned relative to the sleeve by slackening the nut on its end.

Passing through the piece to be tooled is a drilled hole concentric with the required cylindrical surface, and through this the mandril passes. So long as the hole is not more than $2\frac{1}{2}''$ diameter the piece will be held truly by the bushes when they are pressed tightly against the edges.

To steady the mandril during the cutting, the large end of the outer bush is supported in the V groove of the stay X (Fig. 4), which is bolted to the right-hand side of the table by two $\frac{3}{4}''$ bolts as shown in the general drawing on Plate XII.

EXERCISES.

1.—**Stay X.** Draw the two given views, and add an end elevation. *Scale, 6 ins. = 1 foot.*

2.—**Slide L.** From the given views draw the side and front elevations, and a plan projected from the latter. Show in position the brass nut for the vertical screw S_4. *Scale, 6 ins. = 1 foot.*

3.—**Table.** Draw the three given views showing the spindle S_3 and screw, and add a horizontal section—below the spindle—projected from the end elevation. *Scale, 3 ins. = 1 foot.*

4.*—**Table and Slide.** Draw the given views, and show in the plan the pitch cones of the bevel wheels. *Scale, ¼ full size.*

5.—**Circular Motion Mandril.** Draw the elevation, sectional plan, and the sectional elevation taken at right angles to the length of the spindle, showing the worm and the portion of the bed supporting the worm shaft. *Scale, ½ full size.*

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* This Exercise is intended for Advanced Students.

10" STROKE SHAPING MACHINE.

DETAILS OF TABLE AND SLIDE.

Scale 1¾"=1 Foot

SECTIONAL ELEVATION AT A B

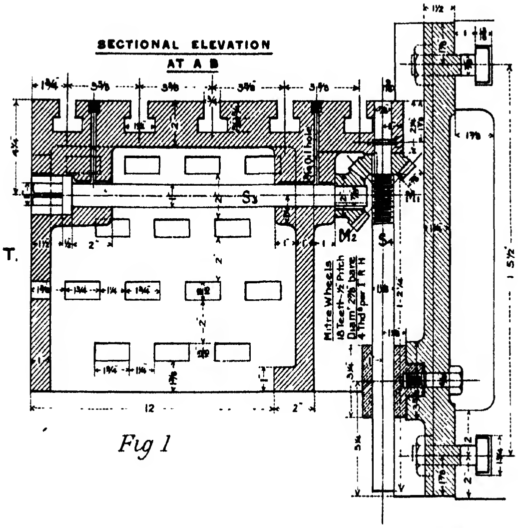


Fig 1

END ELEVATION OF TABLE

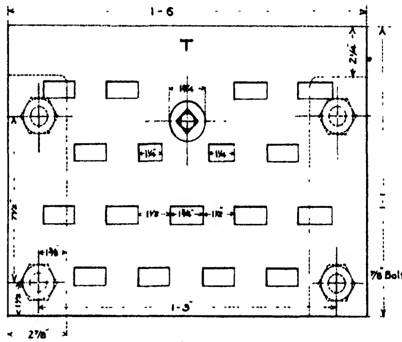
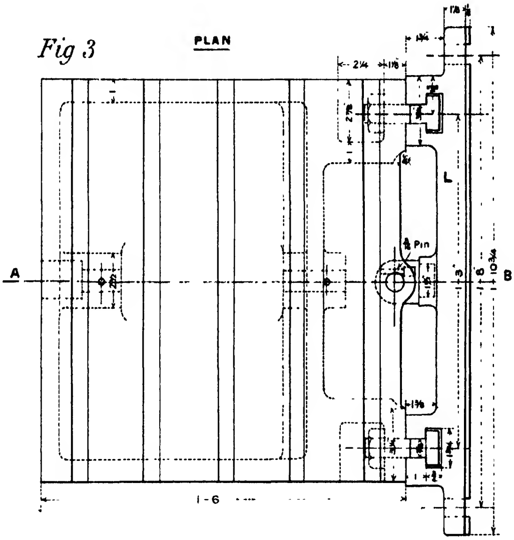


Fig 2.

Fig 3

PLAN



STAY FOR SUPPORTING CIRCULAR MOTION MANDRIL.

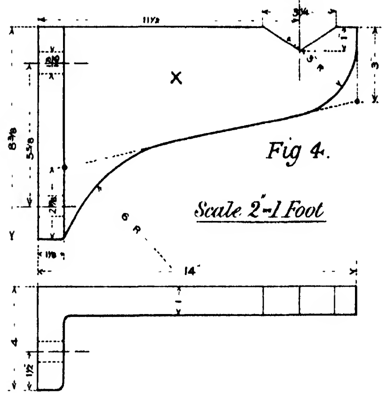


Fig 4.

Scale 2"=1 Foot

CIRCULAR MOTION MANDRIL

SECTIONAL PLAN

Scale 3"=1 Foot

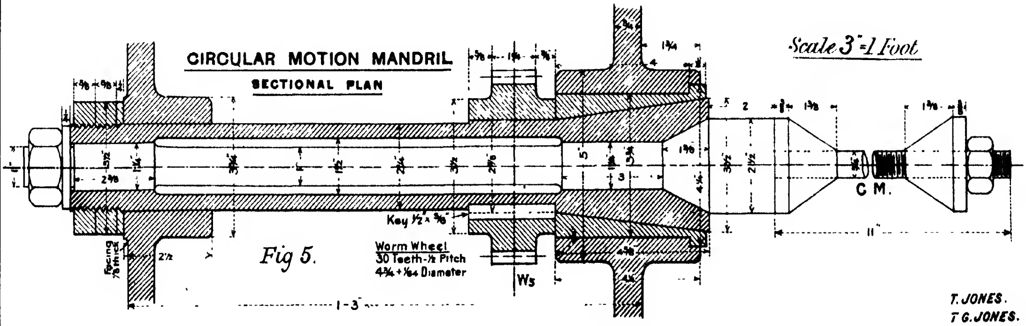


Fig 5.

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Plate XV.—SHAPING MACHINE.

DETAILS OF CARRIAGE, &c.—The carriage **Y** is designed to carry the ram **R** and the mechanism actuating it. As in the Slotting Machine, the quick return of the tool is effected by a slotted arm and driving crank, the arm being connected with the ram by the wrought-iron rod **K**.

The sectional elevation (Fig. 2) shows clearly how the driving pinion and wheel W_1, W_2 respectively are supported at the back of the carriage: W_1 is fitted with a feather key, so that it may receive the motion of the shaft during its travel with the carriage along the bed. On the face of the wheel W_2 is the **T** slot in which the driving pin **P** is adjusted to give the required stroke of the tool. This pin consists of three parts—a cast-iron block sliding in the slot of the arm **S A**, a wrought-iron flanged bush passing through the block, and a $\frac{7}{8}$" bolt to hold them in position on the wheel.

The cast-iron slotted arm is centred on the bracket of the carriage, and has attached to it on one side the rod **K** in such a position that when the pin is at its greatest distance from the centre of the wheel the stroke of the ram is 10". In consequence of the point of attachment of the rod not being on the centre line of the arm, the rate of change of velocity during the first portion of the stroke is greater than that during the latter portion. The maximum velocity occurs a little before half stroke, and assuming the slowest speed of running, *i.e.*, 20·7 revolutions per minute, its value is 38·4ft. per minute for a stroke of 10". (See below for diagrams of velocity.)

The method of determining the ratio of times of cutting and returning for any stroke will be found in the notes on the Slotting Machine, Plate XX.

The carriage is moved over the horizontal face of the bed by the left-hand screw S_1, and its automatic feed per cutting stroke may be varied from ·009" to ·055" by adjusting the link L_1. The strip to take up the wear of the sliding surfaces is held by four $\frac{5}{8}$" screws, and adjusted by three $\frac{1}{2}$" steel set screws.

The ram is constrained to move at right angles to the length of the bed by the parallel bevelled projection and adjustable strip on the carriage, the strip carrying the vertical support for the tool box feed tackle. The connection of the ram with the rod **K** is such that it may be adjusted to bring the tool to any part of the work.

The speed of the driving wheel W_2 is less than that of the driving shaft in the ratio of 12 to 42; therefore, since the speeds of the latter are 198·6, 120, and 72·5 revolutions per minute (see notes to Plate XVII.), the number of cutting stroke may be—

$$198{\cdot}6 \times \frac{12}{42} = 56{\cdot}2 \text{ per min.} \qquad 120 \times \frac{12}{42} = 34{\cdot}3 \text{ per min.} \qquad \text{or, } 72{\cdot}5 \times \frac{12}{42} = 20{\cdot}7 \text{ per min.}$$

EXERCISES.

1.—**Slotted Arm.** Draw two elevations and a plan. *Scale, $\frac{3}{8}$ full size.*

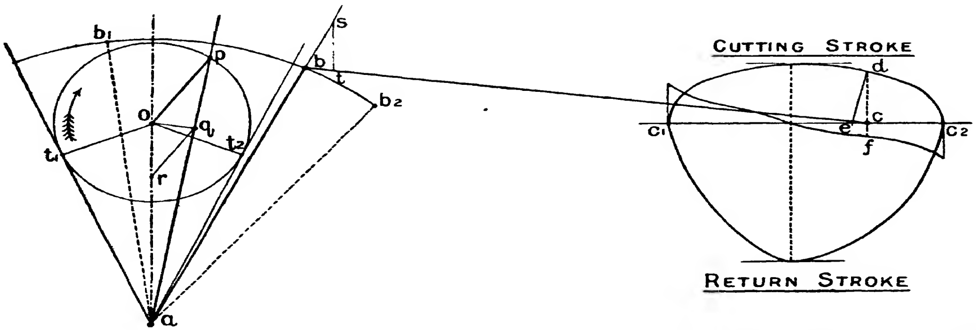
2.*—**Carriage Y.** Draw the following projections:—Side elevation, front and back elevations, plan, projected from the side elevation, and also a vertical section through the driving shaft **D S**. *Scale, 3 ins. = 1 foot.*

3.*—**Carriage, Slotted Arm, Wheels, &c.** Draw the given views, adding—projected from the plan—a vertical section through the feed screw S_1. *Scale, 3 ins. = 1 foot.*

4.—**Fly-wheel.** Draw a side elevation and sectional plan. *Scale, 3 ins. = 1 foot.*

* These Exercises are intended for Advanced Students.

CURVES OF VELOCITY AND ACCELERATION OF TOOL.—The accompanying diagram gives the velocity and acceleration curves of the tool for the cutting stroke, and the velocity curve for the return, when the stroke is the maximum 10".



When dealing with a similar problem on the Slotting Machine, it was assumed that the velocity of the tool was equal to the linear velocity of the end of the arm, because the inclination of the connecting rod to the direction of motion to the tool was, for all positions, very small, but with this machine such is not the case, and the effect of this obliquity must be considered.

Let o be the centre of the driving wheel; a the centre of oscillation of the arm; p the driving pin, whose distance from o is such as to make the travel of the tool equal to 10". The extreme positions of the centre line of the arm are $a\,t_1$ and $a\,t_2$ respectively.

The angular velocity for the position p of the pin is found by drawing oq at right angles to $a\,p$ and qr parallel to op.

Or represents the angular velocity of the arm, and oa the constant angular velocity of the radius op. (For proof, see notes to Plate XX.)

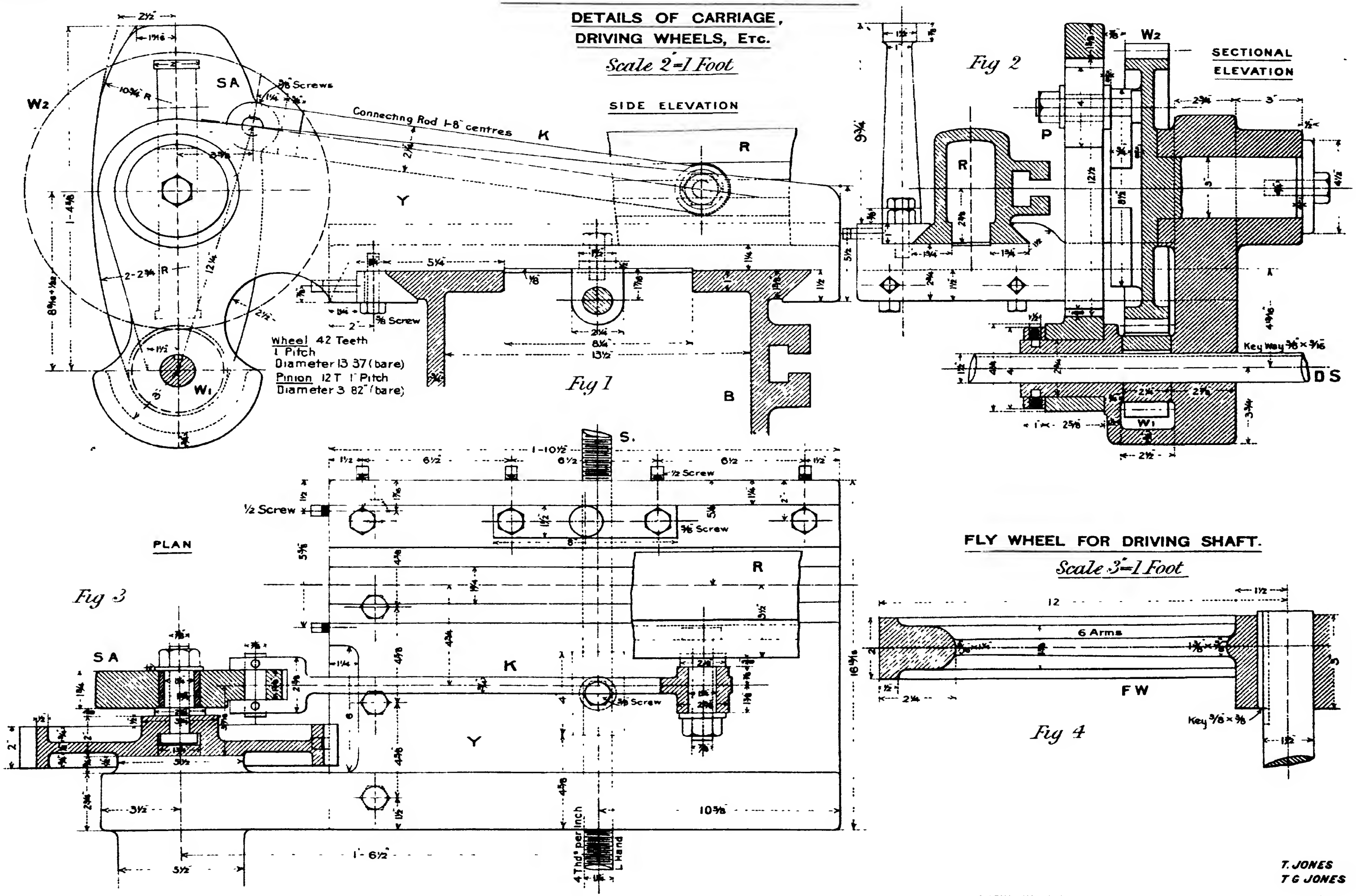
The forked end b of the connecting rod bc is $3\frac{3}{8}$" in front of the centre line of the arm, and therefore ab must be regarded as a crank of variable angular velocity actuating the ram. The extreme positions b_1, b_2 correspond with the respective positions c_1, c_2 of the tool.

[*Continued.*

10" STROKE SHAPING MACHINE.

DETAILS OF CARRIAGE, DRIVING WHEELS, Etc.

Scale 2" = 1 Foot



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O r represents the angular velocity of the arm, but it will now be taken to represent the linear velocity of the point *b*. The ends *b* and *c* of the rod move along the circular arc $b_1\, b\, b_2$ and the straight line $c_1\, c_2$ respectively. For any position the relative velocities of *b* and *c* may be determined graphically by the method of ***instantaneous centre.***

This centre is such that, at the particular instant considered, the distance from it of any point on the moving body is proportional to the linear velocity of that point.

Through the points *c*, *b* draw at right angles to their instantaneous directions of motion, the lines *c* I, *b* I respectively (not shown in the diagram), intersecting in the point I the instantaneous centre of the rod in the position *b c*.

Then, if *b* I represents the linear velocity of *b*, *c* I represents that of *c*.

On *b* I make *b s* equal to *o r*, and from *s* draw *s t* parallel to *c* I, intersecting *b c* in *t*; then *s t* represents the linear velocity of the point *c*, and therefore of the tool for the position *p* of the driving pin. Make *c d* on *c* I equal to *s t*. The locus of *d* is the velocity curve of the tool for the cutting stroke.

The maximum velocity occurs a little before half stroke: for the position *a o* of the arm the linear velocity of *c* is equal to that of *b*, and neglecting the very slight difference between this and the maximum velocity, we may say that the **greatest speed of cutting is 38·4ft. per minute.**

Revolutions of driving wheel $= 20{\cdot}7$ per minute, $o\,p = 3\frac{1}{2}''$, $a\,o = 8\frac{19}{32}''$, $a\,b = 12\frac{1}{4}''$; $\therefore$ velocity of $p = \frac{2}{1} \times \frac{22}{7} \times \frac{7}{2} \times \frac{1}{12} \times 20{\cdot}7 = 37{\cdot}9$ft. per minute;

$$\text{velocity of } b = \frac{37{\cdot}9 \times 12\frac{1}{4}}{12\frac{3}{32}} = 38{\cdot}4\text{ft. per minute.}$$

For a complete explanation and proof of the method of drawing an acceleration curve from a velocity curve on a distance base, see **Kennedy's "Mechanics of Machinery."** The following is the construction:—Draw the normal *d e* to the curve at *d*, intersecting the base in the point *e*. The projection *c e* of *d e* on the base represents the acceleration for the position *c*. $c\,f\,[=c\,e]$ is marked on the ordinate of *d* above or below the base line $c_1\, c_2$ according as the velocity is increasing or decreasing.

Plate XVI.—SHAPING MACHINE.

DETAILS OF TOOL BOX.—The tool box is constructed so that the tool can be made to cut horizontal, inclined, internal and external cylindrical surfaces. It consists of the slides **N** and **O** and the segmental worm wheel **P** carrying the tool holder.

The back slide **N** is fixed to the circular flange of the ram by three $\frac{5}{8}''$ bolts, whose heads fit into a circular **T** groove in the former. To keep the slide central when turned into an inclined position, it moves upon a circular projection on the face of the ram.

Movable over the face of **N** is the slide **O**, carrying on the top and front the worm bracket and wheel segment respectively. The overhanging portion at the top is bevelled inwards at an angle of 50° to receive the curved edge of **P**, which has its centre on the axis of the pin V_c. The brass nut for the feed screw S_s is fixed to **O** by a $\frac{3}{8}''$ set screw as shown in Fig. 2. The dimensions of the adjustable strip for the slide are given in the section at **X Y**.

The worm bracket is recessed to receive the wrought-iron worm **Q**, and its sides are bossed out to support the steel spindle. The malleable iron tool holder **H** on the front of **O** is supported by a pin passing through both, and fitted so that the holder turns slightly upon it when the tool is making the return stroke. The tool is passed into a rectangular recess, $1\frac{3}{8}'' \times 1\frac{1}{8}''$ (the latter dimension is not given on the drawing), and held securely by two $\frac{5}{8}''$ steel screws.

When the slide **N** is vertical the tool can be fed automatically by means of the arrangement shown in Figs. 1, 2, and 4 and the general drawing on Plate XII. Fitting on the square end of the screw S_5 is a short cylinder carrying the ratchet wheel and the two sides of the pawl lever, the latter turning freely on it. On one end of the lever is the pawl, and on the other a simple **U** piece for attachment to the feed rod **F R**, which rod is held horizontally by passing through a swivel on the top of the upright fixed on the carriage. This rod carries stops, one on each side of the swivel, so adjusted that near the end of each stroke a stop comes in contact with the fixed swivel, and in consequence the rod is moved a distance equal to that which the ram has still to travel when the stop is arrested. This motion may be varied within wide limits. The pawl must be placed in gear with the teeth of the ratchet wheel on that side of the lever which will cause the feed to be given at the end of the return stroke.

The amount by which the tool may be tilted, while retaining the vertical feed, is limited by the length of the curved slot in the segmental wheel.

If the tool is to cut a concave cylindrical surface, the locking screw is removed and the worm shaft turned through a small angle at the end of each return stroke. The distance of the point of the tool from the centre of the swivel pin V_c is equal to the radius of the curved surface.

Fig. 3.—The hollow cast-iron ram **R**, movable across the carriage and actuated by the slotted arm and sliding block, carries the tool box on the front end. It is stiffened by two intermediate webs $\frac{5}{8}''$ thick, widened to $2\frac{1}{2}''$ at the bottom. On one side is the **T** slot, which admits of a horizontal adjustment of about 12″. There is a recess on the top, immediately behind the flange, to receive one of the nuts used in fixing the back slide of the tool box.

EXERCISES.

1.—**Ram.** Draw the given side elevation and cross section, and add the plan and back end elevation. *Scale,* $\frac{1}{4}$ *full size.*

2.*—**Back Slide N.** Draw the front and side elevations and plan showing the complete feed gear and the slide fixed on the end of the ram. (See Plate XV. for vertical support of feed rod.) *Scale,* $\frac{1}{2}$ *full size.*

3.*—**Tool Box.** Draw the two given views and add a plan. *Scale,* $\frac{1}{2}$ *full size.*

* These Exercises are intended for Advanced Students.

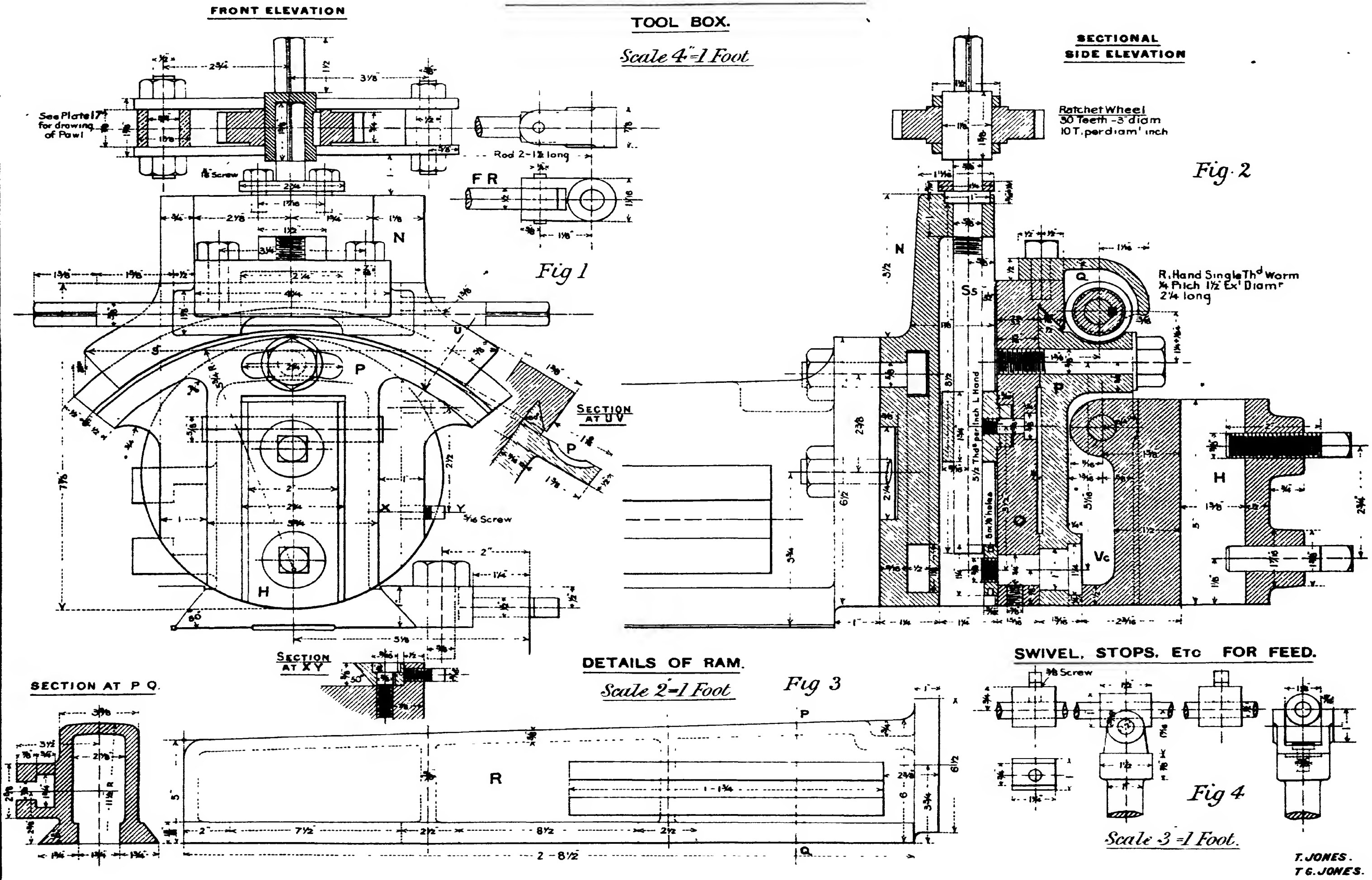
10" STROKE SHAPING MACHINE.
TOOL BOX.
Scale 4"=1 Foot
FRONT ELEVATION
See Plate 17 for drawing of Pawl
Rod 2-1½ long
F R
Fig 1
N
P
H
U
SECTION AT UV
5/16 Screw
SECTION AT XY
SECTIONAL SIDE ELEVATION
Ratchet Wheel
30 Teeth -3" diam
10 T. per diam' inch
Fig. 2
R. Hand Single Thd Worm
¾ Pitch 1½ Ex' Diamr
2¼ long
Q
Ss
5½ Thds per Inch L Hand
Vc
SECTION AT P Q.
DETAILS OF RAM.
Scale 2"=1 Foot
Fig 3
R
SWIVEL, STOPS, ETC FOR FEED.
3/8 Screw
Fig 4
Scale 3"=1 Foot.
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Plate XVII.—SHAPING MACHINE.

DETAILS OF FEED MOTION AND DRIVING PULLEY.—The power is transmitted to the machine through the three speed cone pulley on the driving shaft **DS** connected with an equal pulley on the counter-shaft which makes 120 revolutions per minute. To relieve the boss of the pulley from strain due to the pull of the belt four webs are cast between it and the rim.

The three speeds of the shaft are—

$$\text{Maximum} \ldots\ldots \frac{120 \times 12\frac{5}{8}}{7\frac{5}{8}} = 198{\cdot}6 \text{ revolutions per minute.}$$

$$\text{Intermediate} \ldots \quad = 120 \quad \text{,,} \quad \text{,,}$$

$$\text{Minimum} \ldots\ldots \frac{120 \times 7\frac{5}{8}}{12\frac{5}{8}} = 72{\cdot}5 \quad \text{,,} \quad \text{,,}$$

On the other end of the shaft, outside the arm **E**, is fixed the 2ft. fly wheel, shown on Plate XV., Fig. 4, which ensures more uniform running during the variable speed of cutting.

The feed gear is designed to effect automatically the feeds of the carriage and the circular motion mandril. Carried on the arm **E** are the feed wheel W_4 and the lever **F**; and on the end of the screw S_1 are two wheels G_1 G_2, the former keyed to S_1, and the latter turning freely on the long boss of G_1 and in gear with an equal wheel G_3 on the worm shaft S_2.

The feed pinion W_3, gearing with W_4, is fixed on the driving shaft. The ratio of the numbers of teeth on W_3, W_4 is the same as that of the driving pinion and wheel W_1, W_2 respectively; *i.e.*, $\frac{26}{51} = \frac{12}{42}$, so that the wheel provided with the circular groove for feed makes one revolution per double oscillation of the slotted arm **SA**.

The eccentricity of the groove is $1\frac{1}{4}''$, and therefore the steel bowl on the end of the cast-iron feed lever performs two vertical strokes, each $2\frac{1}{2}''$ long, per revolution. The vibrating motion is transmitted to the cast-iron bell-crank pawl lever L_2 by the link L_1 whose ends are adjusted in the slots to give the required feed. The maximum and minimum angular displacements of L_2 are about 80° and 13° respectively. (See diagram below.)

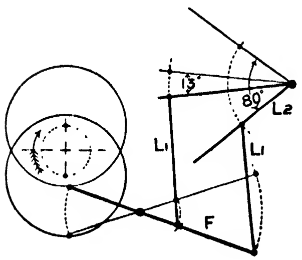
Since the feed groove is circular the pawl lever will be continually moving, the pawl either moving the ratchet wheel forward or slipping over its teeth, and therefore the feed must commence before the end of the return stroke and continue during a portion of the cutting stroke. The best position of W_4 relative to the driving wheel W_2 is determined on the machine itself. Undoubtedly the feed motion would be better if a groove of shape similar to that for the slotting machine were used.

When the feed of the carriage along the bed is required the pawl above the wheel G_1 is turned into gear.

The wheel G_3 is keyed to the worm shaft S_2, so that when wheel G_2 is moved by the pawl the circular motion mandril will receive a slight angular displacement, varying in amount from $\frac{13}{30}$° to $2\frac{2}{3}$° depending upon the position of the link L_1. L_2 turns freely on S_1, and is held in position by a collar pinned to the latter.

Handles are used on the ends of the screw and shaft for rapid adjustment by hand.

CALCULATION OF FEED.—The maximum and minimum angles turned through by the pawl lever are 80° and 13° respectively.



(*a*) *Feed of Carriage.* Pitch of screw = $\frac{1}{4}''$.

Maximum = $\frac{80}{360} \times \frac{1}{4} = \frac{1}{18}''$ [= ·055″] or 18·4 strokes per inch of feed.

Minimum = $\frac{13}{360} \times \frac{1}{4} = \frac{13}{1440}''$ [= ·009″] or 110 strokes per inch of feed.

(*b*) *Angular Feed of Circular Motion Mandril.*—For one revolution of the shaft the wheel moves through $\frac{1}{30}$th of a revolution, or 12°.

$$\text{Maximum} \doteq \frac{80}{360} \times \frac{1}{30} \times \frac{360}{1} = 2\tfrac{2}{3}°.$$

$$\text{Minimum} = 2\tfrac{2}{3} \times \frac{13}{80} = \frac{13}{30}°.$$

EXERCISES.

1.—**Feed Levers.** Draw two elevations and the plan of the feed levers **F**, L_2, and the connecting link, showing the pawls. *Scale, 9 ins. = 1 foot.*

2.*—**Feed Gear and Driving Pulley.** Draw the end and side elevations and plan showing the pulley in the two elevations, and indicating the toothed wheels by their pitch circles. *Scale, 3 ins. = 1 foot.*

* This Exercise is intended for Advanced Students.

10" STROKE SHAPING MACHINE.

DETAILS OF FEED MOTION AND DRIVING PULLEY.

Scale 2" = 1 Foot.

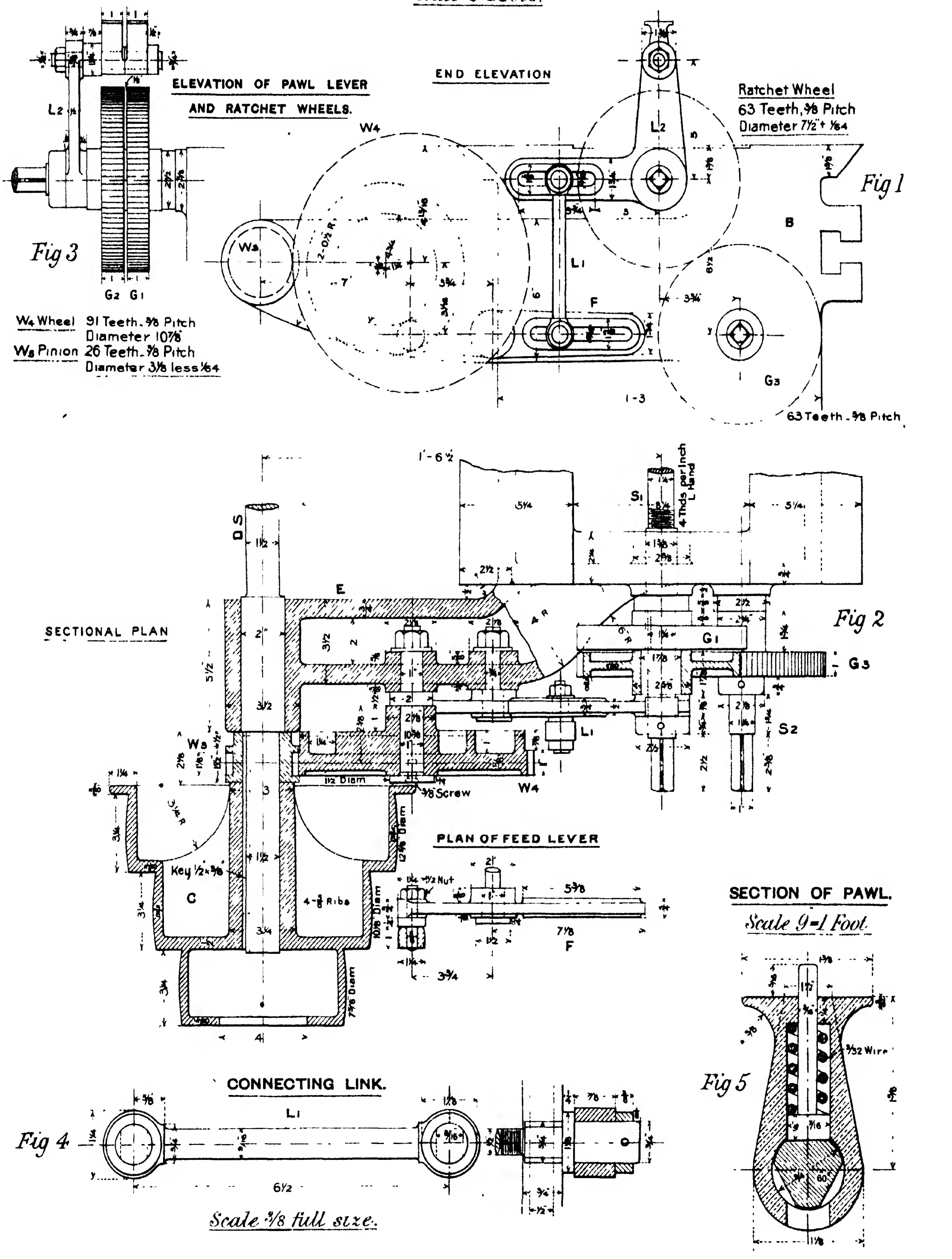


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Plate XVIII.

GENERAL DESCRIPTION.—The slotting machine, of which detailed drawings are given on Plates XIX. to XXIII. inclusive, is made by Messrs. Smith and Coventry Limited, Manchester, and is capable of producing plane and cylindrical vertical surfaces on pieces not exceeding 9 inches in thickness.

All the parts are carried by a substantial frame of box section.

Power is transmitted to the cone pulley from an equal one on the counter-shaft by a $2\frac{1}{4}''$ belt, and passed to the driving shaft of the machine through a pinion and wheel. With the counter shaft making 100 revolutions per minute the speed of the driving shaft may be 27, 17, or $10\frac{1}{2}$ revolutions per minute, according to the position of the belt.

The ram to which the tool is clamped slides against the vertical face of the frame, and is actuated by a slotted arm whose vibrating motion gives to it a reciprocating motion of continually varying velocity. The arm is driven by a pin carried on the driving plate, which is keyed to the shaft. By adjusting the distance of the pin from the centre of the plate the motion of the free end of the arm, and, therefore of the ram to which it is connected by the forked rod, may be varied from 9 inches to zero. With this particular mechanism the return stroke is performed in less time than the cutting stroke, the ratio of the times of cutting and returning decreasing with the stroke.

The tool has a maximum velocity at the middle of its stroke, and for a stroke of 9″ at the slowest speed of running, the maximum velocity of cutting is 18·7ft. per minute. (See notes to Plate XX. for calculation.)

The ram is adjusted for height by the hand wheel carried by it, and then locked to the connecting rod by the nut on the front.

The circular table which supports the work has a worm wheel cast to it, and is constructed with a conical base, the latter fitting in a recess on the top of the cross slide, so that it may revolve when a cylindrical surface is being cut. Motions of the table along and across the horizontal frame slide are obtained by attaching it to the saddle and slide.

Three feeds are possible, and all may be effected automatically or by hand. Fixed to a projection near the long bearing for the driving shaft is a feed lever, whose end fits into a pear-shaped groove on the face of the wheel, and receives at the end of each return stroke a slight vertical displacement. This motion is transmitted along the several arms and links to the three pawl levers, so that when the pawl carried by any one is in gear with its wheel, the work will be fed forward. Mitre wheels carried by the saddle transmit the intermittent vibrating motion of the horizontal feed shaft to the worm shaft, and the screw of the cross slide. With the pawls in the positions shown in the drawings, the feed of the saddle and cross slide would be effected during the down stroke of the feed pin, while the circular feed would take place on its return stroke.

PLATE XVIII.—*Continued.*

Judging from power tests with the slotting machine, carried out at the Baldwin Locomotive Works, U.S.A., its *efficiency* may be taken at *0·75*. For example—the powers required to drive a 12″ stroke machine when empty and fully loaded were 1·5 and 6·5 H.P. respectively; giving a maximum efficiency (efficiency increases with load) of—

$$\frac{6{\cdot}5 - 1{\cdot}5}{6{\cdot}5} = \frac{5}{6{\cdot}5}, \text{ or } 77 \text{ per cent.}$$

The corresponding powers for an 18″ slotter were 2·3 and 10·3 H.P., giving an efficiency of 77·5 per cent.

EXERCISE.

1.*—**Complete Machine**. Draw the front and side elevations.
For half imperial sheet—*Scale, 2 ins. = 1 foot.*
For imperial sheet—*Scale, 3 ins. = 1 foot.*

Plate XIX

The frame is a single casting of $\frac{3}{4}''$ metal, designed to carry all the moving parts of the machine. Its base is large, so that freedom from unsteadiness is ensured without the use of holding-down bolts.

The horizontal surface, over which the saddle moves, consists of two planed strips, $3\frac{1}{4}$in. × 2ft. $1\frac{1}{2}$in., with their outer edges bevelled to an angle of 50°. To afford sufficient bearing area for the ram the frame is widened at the front, and at the top shaped as shown in Fig. 4, Plate XX., to admit of the passage of the connecting rod.

On the right-hand side are two bosses to support the driving shaft, the one near the front being joined to a flat projection which contains the driving plate, and supports the slotted arm. Bosses are also cast on the frame side to support the feed lever F and the horizontal feed shaft F S.

The pulley bracket is made hollow, and cored out through a hole in its under side.

For additional dimensions of the vertical face and pulley bracket see Plates XX. and XXI. respectively.

When drawing the frame it should first be set out in straight lines, as indicated on this plate, in order that the inclinations of its various parts may be obtained. It will be seen that some of the curves are made up of two circular arcs of different radii.

EXERCISE.

1.*—**Machine Frame**. Draw the side and front elevations and plan; indicate in dotted lines the thickness of metal. *Scale, $\frac{1}{8}$ full size.*

* These Exercises are intended for Advanced Students.

9" STROKE SLOTTING MACHINE.

DETAILS OF FRAME.

Scale 1/10 full size

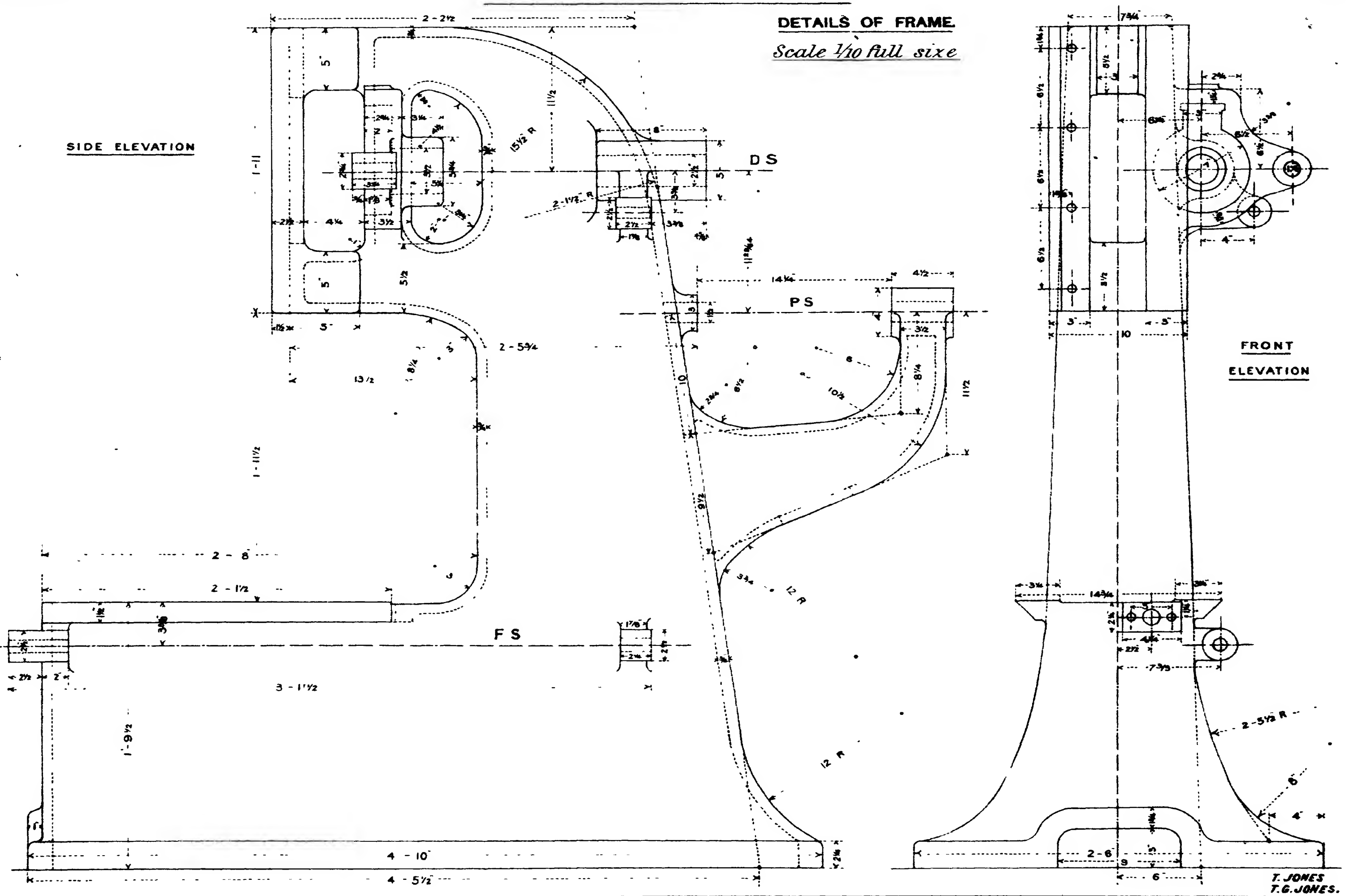


Plate XX.—SLOTTING MACHINE.

THE several views, Figs 1 to 5, show the details of the slotting ram **N** and the means by which it is moved up and down, so that the return stroke may be performed in less time than the cutting stroke.

On one end of the driving shaft **D S** is fixed a cast-iron disc **D P**, which turns in a recess in the side projection near the front of the frame (See Fig. 3). The driving pin **P** is fixed on the face of this disc by two bolts fitting in **T** slots to admit of its adjustment from the centre of the shaft to give the required stroke of tool. To take up the wear of the driving plate the pad **B** is pressed against its edge by means of a screw.

The driving pin carries a rectangular cast-iron block which, sliding in the slot of the arm **S A**, gives it a vibratory motion. When the pin is in its extreme outward position, *i.e.*, $2\frac{1}{4}''$ from the centre of the shaft, the vertical motion of the free end of the arm is 9″—the maximum stroke of the tool. This motion is transmitted to the ram through the cast-iron connecting rod **K**, whose upper end is attached to a prolongation of the nut for the vertical adjusting screw S_1.

The form of the top of the frame, to admit of the motion of the connecting rod, may be clearly seen from the side elevation and plan.

The ram is a long hollow casting with a planed face, which slides against the vertical face of the frame, and is held in position by an adjustable bevelled strip. Its upper part is slotted to receive screw S_1 and admit of the motion of the nut when the ram is being adjusted for height.

The two wrought-iron tool holders **H** are held in horizontal slots formed in the enlarged end.

RATIO OF TIMES OF CUTTING AND RETURNING. (See accompanying diagram.)

Let o be the centre of the driving plate, p the driving pin, and a the centre of oscillation of the arm. When p describes the circle of radius op the arm ab vibrates through the angle b_1ab_2—the vertical distance between b_1 and b_2 being the stroke of the tool. In the diagram $p_1\,p_2$ represents 9″.

When p is at t_1, the point of contact of $a\,b_1$ with the circle, the tool is in its highest position, and with the given direction of rotation the shaft turns through the angle $t_1\,o\,t_2$ $(=2\alpha)$ before the down stroke ends. For the angle of rotation $t_2\,o\,t_1$ $(=2\beta)$ the arm moves from its lowest to its highest position. So, the angles described by the shaft and driving plate during the cutting and return strokes are 2α and 2β respectively, and assuming that the shaft rotates uniformly, the times of cutting and returning are proportional to α and β respectively.

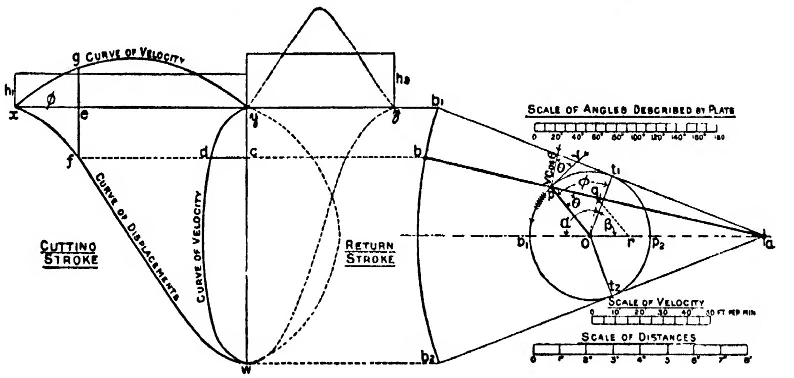
Stroke in inches.	Angle β.	Angle α. $[=180°-\beta]$	$\frac{\alpha}{\beta}$	Revs. per min. of driving plate.	Max. vel. of tool in feet per min.
9	69·75°	110·25°	1·58	10·7	18·7
8	72·05°	107·95°	1·50	10·7	17·2
7	74·33°	105·66°	1·42	10·7	15·45
6	76·66°	103·33°	1·35	10·7	13·65
5	78·9°	101·1°	1·28	17·14	18·85
4	81·13°	98·87°	1·22	17·14	15·33
3	83·37°	96·63°	1·16	27·43	19·3

or, $$\frac{\text{Time of cutting}}{\text{Time of return}} = \frac{\alpha}{\beta}$$

The value of this ratio for any stroke from 9″ to 3″ is given in the accompanying table.

$$\text{Cos}\ \beta = \frac{\text{Throw of pin}}{oa} = \frac{\frac{1}{2}\ \text{stroke}}{ab}$$

The value of β is then obtained from trigonometrical tables. Again $\alpha = 180° - \beta$.



VARIABLE VELOCITY OF TOOL.—The velocity of the tool is continually changing; for the positions t_1, t_2 of the pin its velocity is zero, and is a maximum in the cutting and return strokes when at p_1, p_2 respectively.

The *maximum velocity* during the *cutting stroke* may be determined as follows:—

Let n = revolutions of driving plate per minute, r = radius op in feet, then velocity v of pin in feet per minute = $2\pi r\,n$.

The point on the arm in contact with the pin at p_1 has a velocity v, $\therefore$ velocity of end $b = \frac{v \times ab}{ap_1}$ feet per minute.

From the notes to Plate XXI. it will be seen that the three possible speeds of the shaft are 10·7, 17·14 and 27·43 revolutions per minute.

Assuming the shaft makes 10·7 revolutions per minute, then the maximum cutting speed of tool, when the stroke is 9″ is calculated to be 18·7 feet per minute: where $r = 2\frac{1}{4}''$, $ap_1 = 8\frac{3}{4}''$ and $ab = 13''$.

For the same maximum speed of cutting, the rate of rotation must increase as the stroke diminishes.

[*Continued.*

See letterpress to Plate XXII. for Exercises.

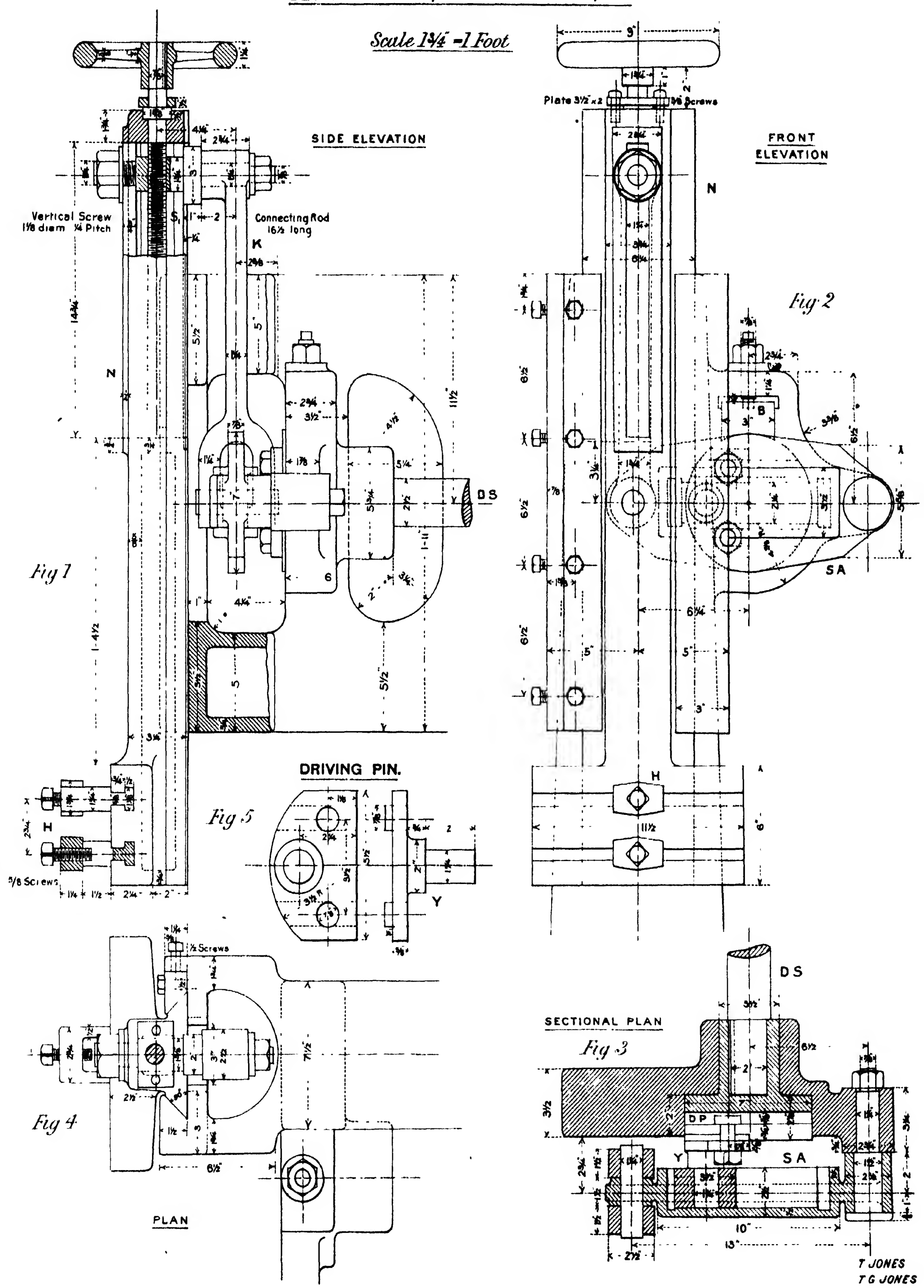
Book 2.

PLATE XX

9" STROKE SLOTTING MACHINE.

DETAILS OF RAM, OSCILLATING ARM, Etc.

Scale 1¼" = 1 Foot



TO DETERMINE THE ANGULAR VELOCITY OF THE ARM FOR ANY POSITION OF THE DRIVING PIN

Let θ = angle between radius op and arm ab.

ω_a, ω_c = angular velocities of arm and radius op respectively.

v = linear velocity of pin p.

$$\omega_c = \frac{v}{op}, \quad \omega_a = \frac{v\cos\theta}{ap} \quad \therefore \quad \frac{\omega_a}{\omega_c} = \frac{\dfrac{v\cos\theta}{ap}}{\dfrac{v}{op}} = \frac{op\cos\theta}{ap}$$

If oq is at right angles to ab and qr parallel to op, then $op\cos\theta = qp \;\therefore\; \frac{\omega_a}{\omega_c} = \frac{qp}{ap} = \frac{or}{oa}$

Hence, oa of constant length represents the constant angular velocity of the driving plate, and or, the instantaneous angular velocity of the arm.

To a different scale or represents the linear velocity of the end b of the arm and of the tool.

The maximum angular velocity during the cutting stroke is not determined by this construction, but geometrically as a fourth proportional. $ap_1 : ao :: op : \omega_a$.

Diagrams of displacement and velocity.

Through the point b_1 draw the line xyz parallel to the centre line ao, and make xy and yz to represent the angles 2α and 2β respectively. They may conveniently be made equal to the arcs $t_1p_1t_2$ and $t_2p_2t_1$ respectively, the arcs which those angles subtend.

Through the points e, b, where xe represents the angle ϕ, draw lines respectively perpendicular and parallel to the line of centres, and make $cd = eg = or$ to represent the linear velocity of b. Then, ef represents the displacement of the tool from its highest position, and eg its velocity when the driving plate has described the angle ϕ after the beginning of the stroke: also, for the displacement $yc\,[=ef]$ the velocity of the tool is represented by cd.

The loci of the points f, g, d are the displacement curve and the velocity curves on time and distance bases respectively.

The corresponding curves for the return stroke are drawn in a similar manner.

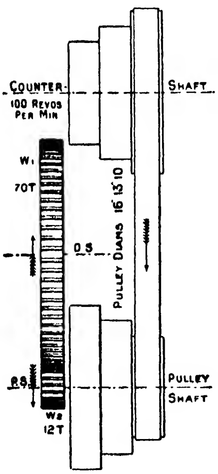
The scale of velocity can be drawn when the maximum velocity is calculated and the line which represents it determined graphically as suggested above.

The ratio of the mean heights h_2, h_1 of the velocity diagrams on time bases is equal to the ratio of the angles described by the plate during the cutting and return strokes.

Plate XXI.—SLOTTING MACHINE.

THE pulley shaft P S is carried at its ends by the frame and the bracket, and is prevented from turning by a screw passing half through the boss of the bracket and half through the shaft. Turning freely on it is the cone pulley C, to the front plate of which the pinion W_2 is keyed. Oil is passed to the shaft through the two small brass tubes. The pulley receives its motion from an equal pulley keyed on the counter-shaft running at 100 revolutions per minute.

Above the pinion, and gearing with it, is the spur wheel W_1, keyed to the driving shaft D S. On the inner face of the wheel is a groove G, so shaped that during a small fraction of a revolution the pin fitting in it receives a vertical motion of $\frac{5}{8}''$ down and up, and then remains in its highest position until the completion of the revolution.



By a combination of levers and links this motion effects the feed of the machine table in any horizontal direction. In order that the feed may take place before the beginning of a new cut, the driving plate must be keyed to the shaft in such a position that the pin receives its motion in the interval between the tool leaving and again reaching the work.

The first feed lever F is centred to a projection on the side of the frame, and in consequence of its connection with the arm A_1 by the rod R, whose ends may be fixed in any positions in the slots, the angular motion of the feed shaft F S may be varied from 5° to 30°.

(1)—*Pulley Shaft.* **SPEED OF PULLEY AND DRIVING SHAFT.**

Maximum speed	=	$100 \times \frac{16}{10}$	=	160 revolutions per minute.	
Intermediate ,,			=	100 ,,	,,
Minimum ,,	=	$\frac{100 \times 10}{16}$	=	62·5 ,,	,,

(2)—*Driving Shaft.*

The speed is reduced in the ratio of 12 to 70 by the wheel gearing.

Maximum speed	=	$\frac{160 \times 12}{70}$	=	27·4 revolutions per minute.	
Intermediate ,,	=	$\frac{100 \times 12}{70}$	=	17·14 ,,	,,
Minimum ,,	=	$\frac{62{\cdot}5 \times 12}{70}$	=	10·7 ,,	,,

The table facing Plate XX. shows what speed is suitable for any particular stroke.

See letterpress to Plate XXII. for Exercises.

9" STROKE SLOTTING MACHINE.

DETAILS OF DRIVING PULLEY, WHEELS, AND LEVERS FOR FEED MOTION.

Scale 1¾" = 1 Foot

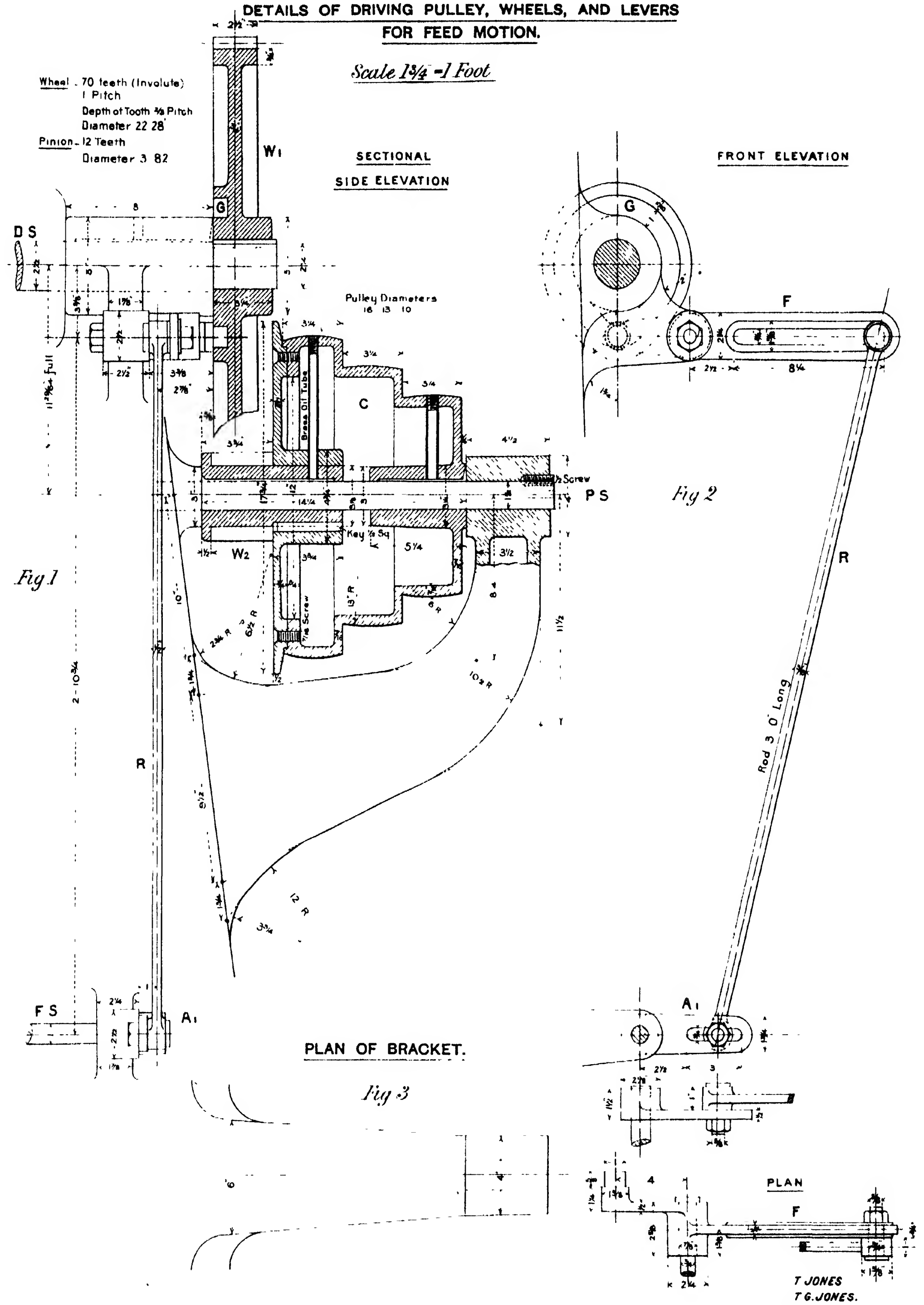


Plate XXII.—SLOTTING MACHINE.

THE table and slides are so arranged that the former, and the work fixed to it, may receive motion in either of two horizontal directions at right angles, or a circular motion.

THE SADDLE D moves over the horizontal planed face of the frame, actuated by the left-hand screw S_2 which is supported at its outer end by the frame. The feed, when effected automatically, may be varied from $\frac{1}{45}$th to $\frac{1}{270}$th of an inch per cutting stroke. An ordinary bevelled adjustable strip is used to follow up the wear of the sliding surfaces.

Cast with the saddle are two arms to support the worm shaft W S, and two bosses to carry the feed mitre wheel M_1, and the shaft of the wheel M_2 and cast-iron lever K. The worm shaft is held endways by a shoulder near one end and lock nuts on the other.

THE SLIDE E is moved across the saddle by the screw S_3, and carries the circular table T.

The worm bracket, supporting the shaft immediately on each side of the wrought-iron worm, is fixed to the side of the slide by two $\frac{5}{8}''$ screws. In order that the worm may receive the angular motion of the shaft for all positions of the slide, it is fitted with a feather key which slides along a key groove in the shaft.

To admit of circular motion the table is formed with a conical base which fits in a corresponding semi-circular recess in the slide, and is held in position by the lock strip L S. The $\frac{3}{4}''$ screw is used for locking the table when no circular motion is required, and the $\frac{3}{4}''$ stud is permanently adjusted to give a correct working fit to the table when the locking screw is released.

The two parallel edges of the strip are bevelled to an angle of 50°, and at the bottom are $10\frac{1}{2}''$ apart, so that the table base, 10″ diameter, may easily be passed into its position.

The maximum automatic feeds of the slide and table are $\frac{1}{45}''$ and $\frac{1}{3}°$ respectively per cutting stroke. (See notes to Plate XXIII. for the method of determining the amount of feed.)

The nuts for the two screws, S_2, S_3 are of brass, and are held in position by circular projections upon them fitting into holes in the saddle and slide respectively.

EXERCISES.

Plate XX.

1.—**Ram.** Draw the front and sectional side elevations and plan showing the feed screw and the tool holders. *Scale, 4 ins. = 1 foot.*

2.—**Slotted Arm and Driving Plate.** Draw the front and side elevations, plan and sectional plan; show also the arm of the frame which carries them. *Scale, ½ full size.*

3.*—**Ram, Arm, &c.** Draw the four given views to a *Scale of ¼ full size.*

Plate XXI.

4.—**Driving Pulley and Bracket.** Draw the sectional side elevation and plan. *Scale, 4 ins = 1 foot.*

5.*—**Driving Pulley, Wheels and Feed Levers.** Draw the given sectional side elevation, and also an elevation looking on the end of the bracket. In the latter view omit the wheel W_1, but indicate, in dotted lines, the cam groove on its face.

Refer to Plate XIX. for relative positions of pulley and driving shafts. *Scale, 3 ins. = 1 foot.*

Plate XXII.

6.—**Table.** Draw the elevation—half in section—and the plan. *Scale, 4 ins. = 1 foot.*

7.—**Slide E.** Draw two elevations and a plan of the slide, showing the locking strip and worm bracket. *Scale, ½ full size.*

8.—**Saddle D.** Draw two elevations and a plan. *Scale, 4 ins. = 1 foot.*

9.*—**Table and Slides.** Draw the front elevation, side elevation—half in section—and plan. Draw the plan of the table apart from the plan of the slides. *Scale, 4 ins. = 1 foot.*

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* These Exercises are intended for Advanced Students.

9" STROKE SLOTTING MACHINE.

DETAILS OF TABLE AND SLIDES.

Scale 2" = 1 Foot

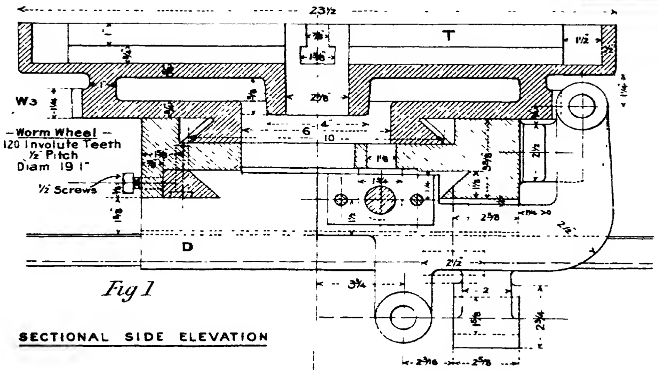


Fig 1

SECTIONAL SIDE ELEVATION

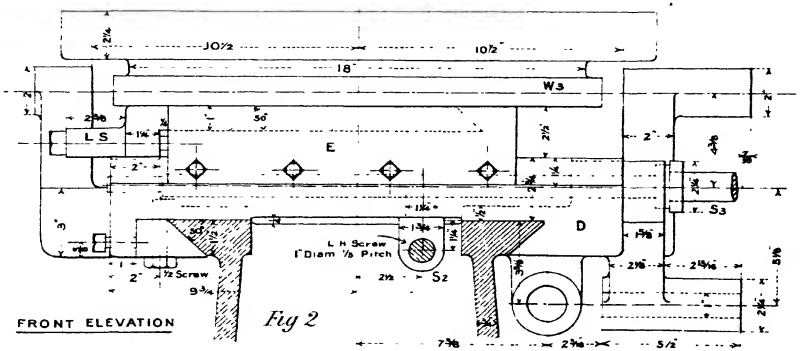
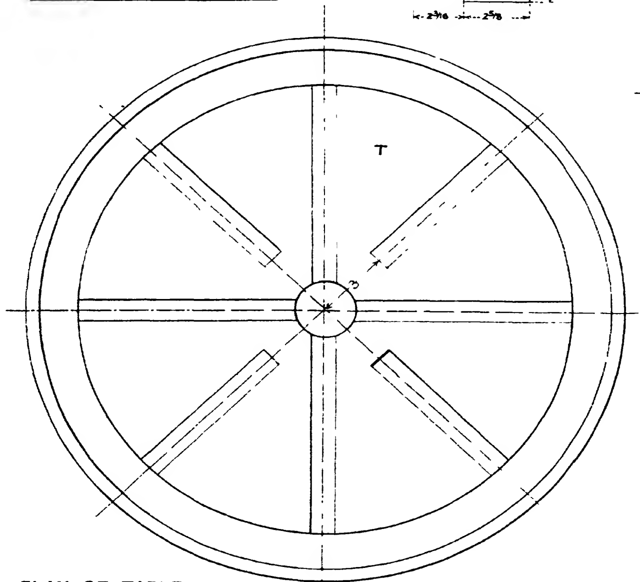


Fig 2

FRONT ELEVATION



PLAN OF TABLE.

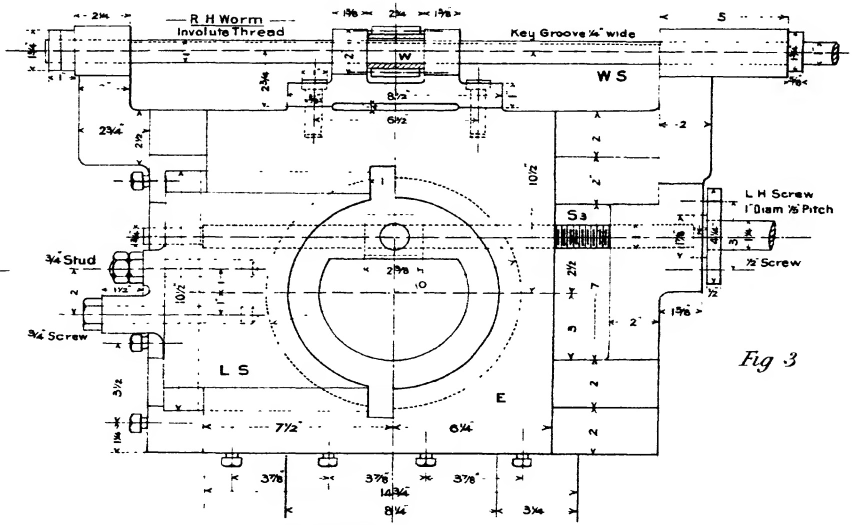


Fig 3

PLAN WITH TABLE REMOVED.

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Plate XXIII.—SLOTTING MACHINE.

FEED MOTION.—Figs. 1 to 7 show the arrangement of levers &c., by means of which the intermittent motion of the feed lever **F** is transmitted to the screws S_2, S_3 and the worm shaft **W S**. The horizontal feed shaft **F S** is supported at its ends by simple bearings cast on the side of the frame, and immediately outside these are fixed the arms A_1, A_2: the former is connected with the feed lever **F** by the rod **R**, and the latter is used to transmit the motion of the shaft to the pawl lever V_1 which is free to turn on the end of the screw.

To connect the screw S_3 and the worm shaft with **F S**, mitre wheels M_1, M_2 are used. M_1 slides along the shaft, being carried by the bearing formed with the saddle as shown in Fig. 7, and M_2 is keyed to a short shaft which is also supported by the saddle. By means of the links L_2, L_3 the motion of the lever **K** is transmitted to the pawl levers V_2, V_3 respectively.

When the pawl is in gear with the ratchet wheel, during the motion of the lever in one direction, the shaft or screw carrying the wheel is turned and so the feed given.

It will be seen that a pawl lever is formed of two cast-iron pieces separated by a pawl and one end of a link.

In order that the pawl may not tend to change its position when in or out of gear with the wheel, the pin carrying it has three flat faces as shown in Fig. 6, against one of which presses the small plunger contained within the pawl.

This simple device enables it to be maintained in three positions, viz., in gear on either side of the lever and out of gear.

For the rapid adjustment and hand feed of the table the ends of the screws and the shaft project beyond the pawl levers, and are of square section to receive the handles.

DETERMINATION OF FEED.—Assuming the given positions of the levers to correspond with the highest position of the feed pin (*i.e.*, before the beginning of the feed) when the rod **R** is adjusted for maximum feed, the angular advance of each of the pawl levers V_1, V_2, V_3, at the end of the return stroke, is about 40°—this being produced by a motion of 30° of the arm A_2.

The smallest possible motion of A_2 is 5°, and it will be sufficiently accurate to say that the minimum motion of a pawl lever is $\frac{1}{6}$th of the maximum.

Maximum feed of saddle or slide $= \frac{40}{360} \times$ pitch of screw $= \frac{40}{360} \times \frac{1}{5} = \frac{1}{45}''$.

Minimum feed $= \frac{1}{6} \times \frac{1}{45} = \frac{1}{270}''$.

For one revolution of the worm the wheel turns through $\frac{1}{120}$th of a revolution, since it has 120 teeth, and therefore for a motion of 40° of the former the latter moves through $\frac{40}{360} \times \frac{1}{120} \times \frac{360}{1} = \frac{1^\circ}{3}$.

EXERCISES.

1.—**Ratchet Wheel, Pawl, and Arm V_3.** Draw *full size* two elevations and a plan, showing the teeth, and in the side elevation the pawl in section as given in Fig. 6.

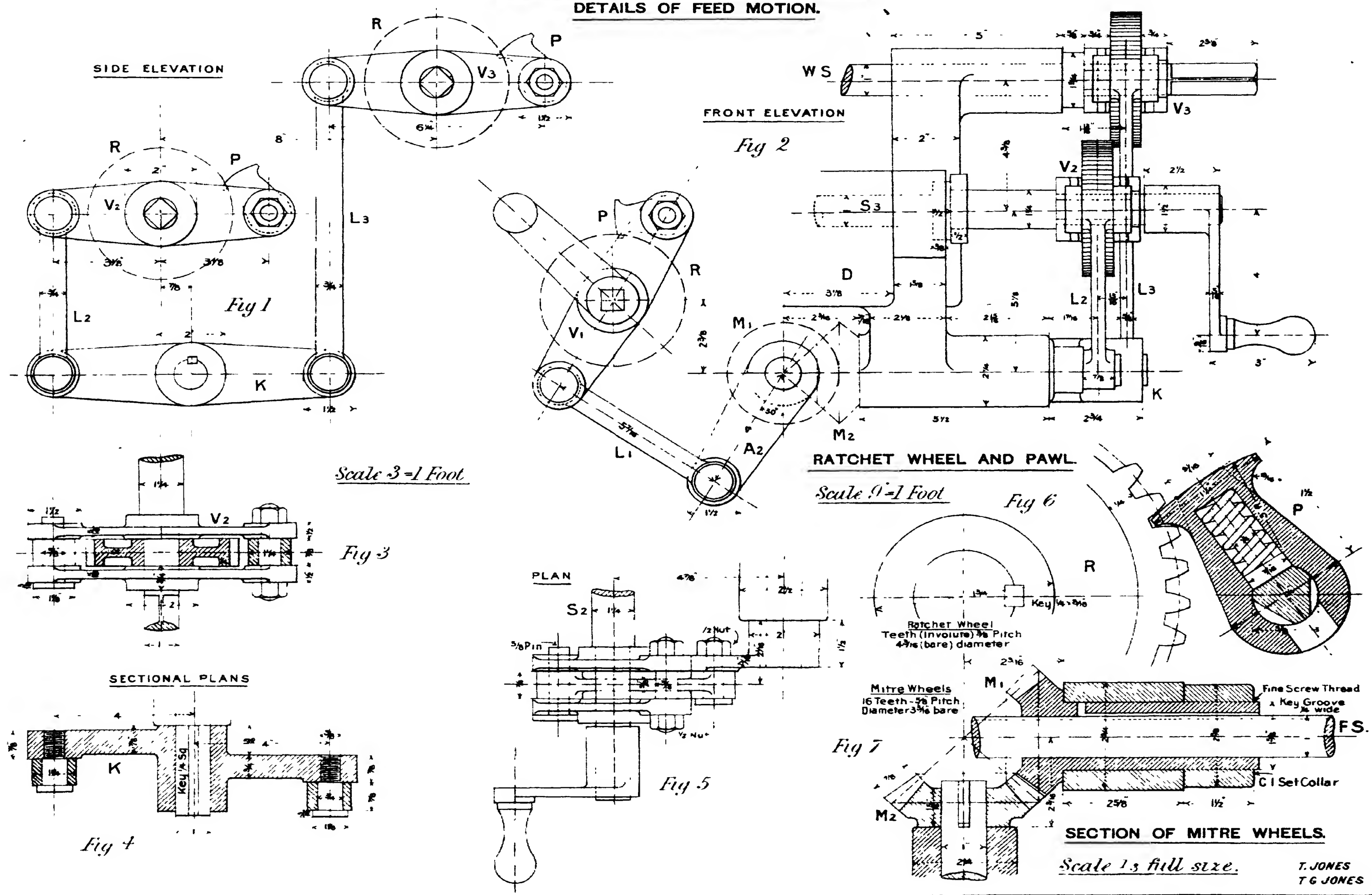
2.*—**Feed Levers and Wheels.** Draw the front and side elevations and plan of the levers and wheels used in the transmission of the intermittent motion of the horizontal feed shaft **FS** to the cross slide **E** and table. (See general drawing for arrangement.) *Scale, ½ full size.*

3.*—**Feed Levers and Wheels.** Draw the front and side elevations and plan of the levers and wheels used in the transmission of motion from the shaft **F S** to the saddle **D**. *Scale, ½ full size.*

* These Exercises are intended for Advanced Students.

9" STROKE SLOTTING MACHINE.

DETAILS OF FEED MOTION.



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BORING AND TURNING MILL.

GENERAL DESCRIPTION.—The Boring and Turning Mill represented in the accompanying illustration, and of which detail drawings are given on Plates XXIV. to XXXVIII. inclusive, is made by Messrs. Geo. Richards and Co. Ltd., Broadheath, Manchester. All the parts have been designed with special regard to the requirements at the present time for heavy cutting with coarse feeds. The machine is capable of operating on pieces not exceeding 48″ diameter, with a maximum height of 36″ under the cross slide, or 30″ under the tool holders.

The counter-shaft may be run at two different speeds, viz., 300 and 263 revolutions per minute; and the motion is transmitted from a four-speed pulley to an equal one on the machine shaft by an open belt.

The driving gear is carried by a separate bed-plate, which is bolted to the side of the machine bed; and the table, carried in a special form of large vertical bearing in the bed, receives its motion from the driving shaft through a pair of bevel wheels and pinion and large spur wheel. The speed of the table may be varied within very wide limits to suit all sizes of work, viz., from 35·6 to 1·687 revolutions per minute, with twenty-two intermediate speeds.

The two standards or uprights are bolted to the horizontal faces at the back of the bed, and are connected at the top by a strong cast-iron stay. The cross slide has long bearings on the uprights, and is moved up or down by a belt arrangement which gives motion to spur gearing carried on a movable arm, and thence to bevel gearing connected with the two vertical screws in the standards The two saddles which carry the tool bars are moved independently along the cross slide either automatically or by hand.

Attached to each side of the bed is a patent feed gear box, and the gearing is so compactly arranged that, by turning the operating handle through one-third of a revolution, the full number of changes (four) can be made. Leading from each gear box is a vertical feed shaft, which transmits the feed motion to a three change system of sliding wheels mounted at the end of the cross slide: so that, in all, twelve rates of feed are obtained, varying from ·7877″ to ·0276″ for the cross feed, and from ·7963″ to ·0279″ for the down feed per revolution of the table.

The tool bars are balanced by a patent spring arrangement which does away entirely with the use of weights and chains, and does not in any way impede the operator in the manipulation of the machine.

The weight of the machine is about 6 tons.

EXERCISE.*

Complete Machine. Draw the front elevation, and the side elevation to the right of the front elevation. Use paper of "Imperial" size. *Scale, 1½ ins. = 1 foot.*

Plate XXIV.

MACHINE BED.—The bed is a large single casting designed to carry the table and the two standards, and to give support to all the main gearing. The front central portion is semi-circular, and passing vertically through it is a bearing 10″ diameter, for the trunnion of the table, terminating at the top in a large annular conical bearing which is lined with anti-friction metal.

On the planed tops of the two parallel sides of the bed are bolted the right-hand and the left-hand standard. To the two box-shaped projections on the left-hand side is bolted the end of the bed-plate for the driving gear; and this side of the bed is also provided with two long bearings for the support of the main and the back-gearing shafts.

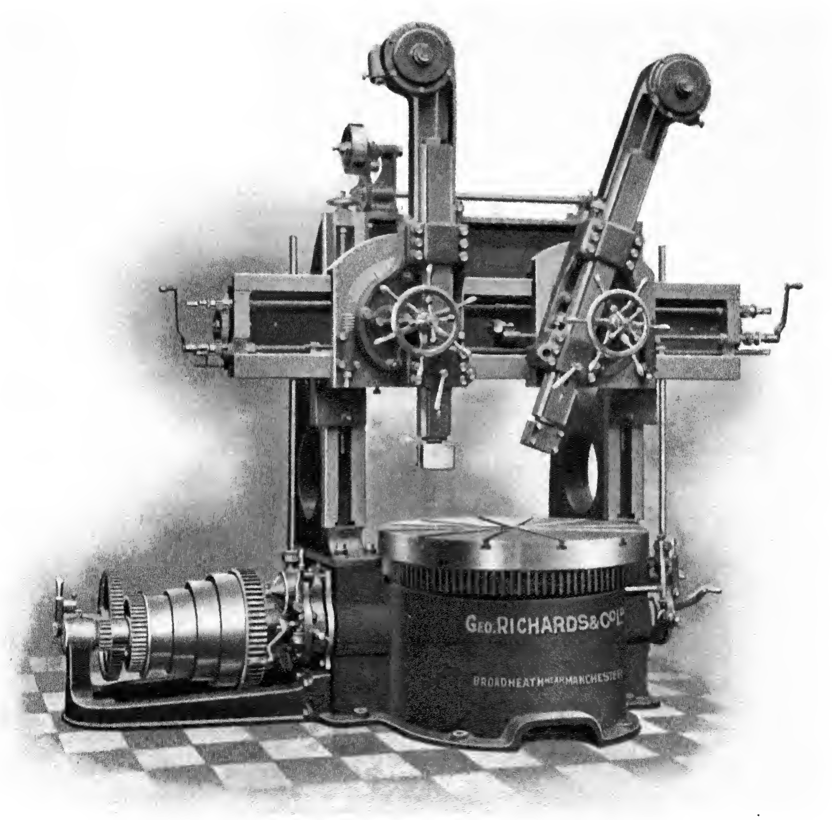
The feed gear boxes—detailed on Plates XXXIII. and XXXIV.—are fixed to the bed in the positions indicated in Fig. 1; and the feed shaft FS_1, which receives its motion from the main shaft through the two chain wheels C_1, C_2, runs right through the bed and serves to actuate both sets of feed wheels.

EXERCISE.*

Machine Bed. Draw the three given views, indicating by dotted lines in the side elevation the thickness of metal of all the parts. *Scale, 3 ins. = 1 foot.*

* These Exercises are intended for Advanced Students.

BORING AND TURNING MILL.



CONSTRUCTED BY MESSRS. GEO. RICHARDS & CO. LTD., BROADHEATH, MANCHESTER.

Book 2.

48-INCH BORING AND TURNING MILL.

PLATE XXIV

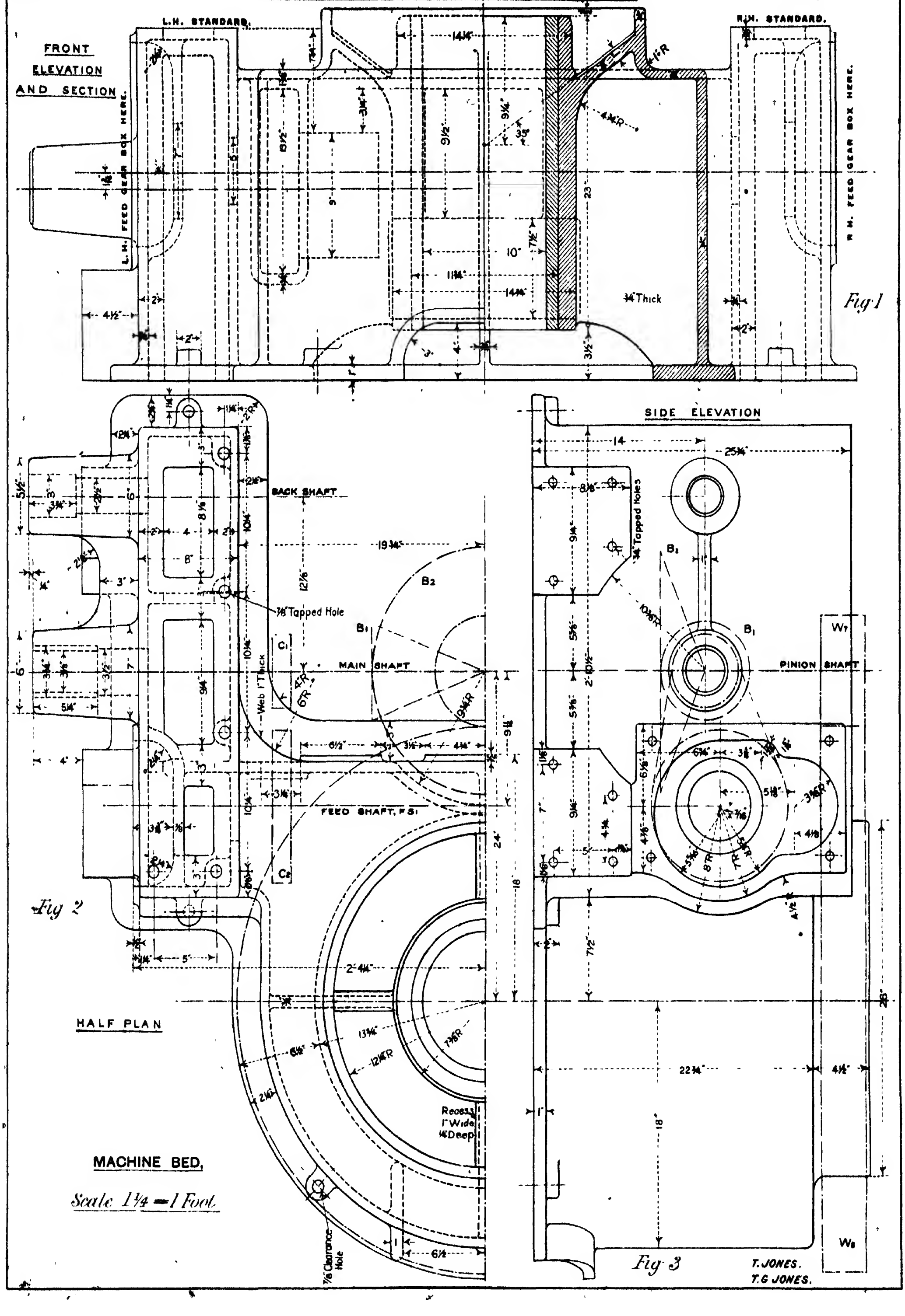


Plate XXV.—BORING AND TURNING MILL.

TABLE.—The table is 44″ diameter, $4\frac{3}{8}$″ deep on the edge, and is provided with twelve radial T slots for the holding-down bolts. The several circular concentric projections on the underside are well stiffened by $\frac{3}{4}$″ radial webs.

The trunnion, a hollow cylinder 10″ outside diameter by 26″ long, rotates in the bearing formed in the bed. Its upper end which is considerably enlarged, provides a conical surface to take the vertical pressure on the table, and at the same time ensures uniform wear over the rubbing surfaces together with rigidity. The table is secured to the trunnion by six $\frac{3}{4}$″ screws, and the whole is held down by a collar which is fixed by $\frac{3}{4}$″ "grub" screws to the lower end of the trunnion.

The conical annular bearing in the bed has a lining of anti-friction metal, $\frac{1}{2}$″ thick, which is prevented from turning by ribs on its underside. The surfaces move in a reservoir of oil, being connected by a horizontal pipe passing through the machine bed to a stand-pipe which contains oil to such a height as to bring the oil level to the position shown in the drawing. (This oil stand-pipe is seen in the half-tone illustration a little to the right of and on the same level as the table.)

The cast-iron wheel W_6, by means of which the table is rotated, has 100 teeth ($2\frac{1}{2}$ teeth per diametral inch; diameter $= \frac{100}{2\frac{1}{2}} = 40''$) and is fixed concentrically to the table by twelve $\frac{3}{4}$″ screws as shown. The force necessary to overcome the resistance to cutting is transmitted through these screws, hence the importance of having a large number accurately fitting the holes.

As will be seen from the calculations of speeds in the notes to Plates XXVI. and XXVII. the table may be run at twenty-four different speeds, varying from 35·6 to 1·687 revolutions per minute to suit all sizes of pieces to be tooled. If the table be running at the lowest speed, *i.e.* 1·687 revolutions per minute, and the machine turning the maximum diameter of 48″, then—

$$\text{the cutting speed} = \frac{48}{12} \times \frac{22}{7} \times 1{\cdot}687 = 21{\cdot}2 \text{ ft. per minute.}$$

EXERCISES.

1.—**Table.** Draw the two half sectional elevations as shown, the complete plan and an outside elevation to the right of the plan. *Scale, 3 ins. = 1 foot.*

2.—**Trunnion.** Draw the half sectional elevation and half outside elevation and plan. *Scale, 4 ins. = 1 foot.*

3.*—**Table and Trunnion.** Draw the two given views, but show half the trunnion in outside elevation. *Scale, 3 ins. = 1 foot.*

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* This Exercise is intended for Advanced Students.

Book 2. **48-INCH BORING AND TURNING MILL.** PLATE XXV

TABLE AND TRUNNION.

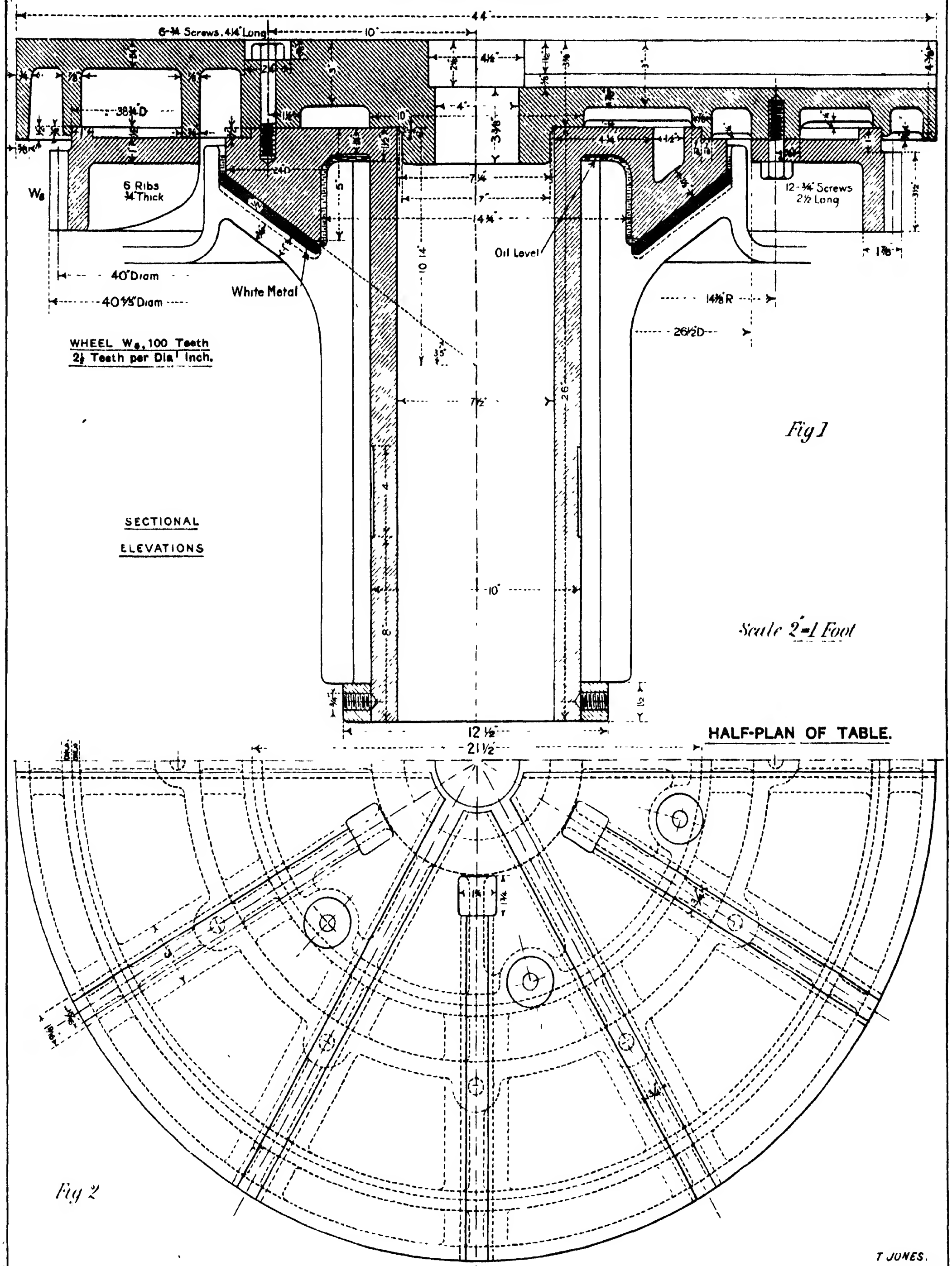

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Plate XXVI.—BORING AND TURNING MILL.

GEARING ATTACHED TO THE BED.—In Figs. 1 and 2 is shown the gearing for the transmission of the motion of the main shaft to the table, and also to the feed shaft FS_1. As previously mentioned the separate bed-plate for the driving gear—detailed on Plate XXVII.—is bolted to the left-hand side of the machine bed; and the main shaft, supported in a long bearing, passes through the bed into the space immediately behind the table. The end of the shaft is supported by a brass-bushed bracket—detailed in Fig. 4—and immediately beyond the bracket is the steel bevel pinion B_1, which gears with the bevel wheel B_2 on the vertical pinion shaft. (It will be seen from the drawings that the bed is dished out for the wheel B_2.)

The stout pinion shaft is supported by a bracket—detailed in Fig. 3—which furnishes ample bearing for the shaft, and receives the vertical pressure through the collar at the top end of the shaft. These two brackets are secured to the facings on the bed by $\frac{3}{4}''$ screws, and, to relieve the screws of the shearing stress due to the dead weight, the vertical face of each bracket is formed with a horizontal projection $\frac{1}{4}''$ wide, which bears on the upper planed edge of the facing. The steel pinion W_7 is keyed to the upper end of the vertical shaft, and gears with the large spur wheel W_8 attached to the table.

The feed shaft FS_1 runs through the bed parallel to the main shaft, and gives motion to the gearing contained within the two feed gear boxes: this shaft receives its motion from the main shaft through a pair of chain wheels, C_1, C_2, of such diameters that the speed is reduced in the ratio of 1 to $\frac{27}{16}$. The large wheel C_2 is almost entirely enclosed within the bed, and the exposed chain and the wheel C_1 are completely covered by the chain wheel case.

By means of the bevel wheels B_1, B_2, and the spur gearing W_7, W_8, the speed of rotation of the table is less than that of the main shaft in the ratio of $\frac{B_1 \times W_7}{B_2 \times W_8} : 1$, *i.e.*, $\frac{18 \times 20}{45 \times 100} : 1$, or 1 to 12·5.

$$\therefore \text{ Revolutions per minute of table} = \frac{\text{Revolutions per minute of main shaft}}{12{\cdot}5.}$$

From the calculations of speeds in the notes to Plate XXVII., it will be seen that the twenty-four possible speeds of the main shaft are approximately :—

446, 391, 342, 300, 263, 231, 202, 177 (Single gear).
151, 132·6, 116, 102, 89·5, 78·5, 68·5, 60 (Intermediate gear).
53·2, 46·6, 40·7, 35·7, 31·4, 27·8, 24, 21·1 (Full gear).

And, therefore, the corresponding speeds of the table are :—

35·6, 31·2, 27·4, 24, 21, 18·5, 16·1, 14·1 (Single gear).
12·1, 10·6, 9·3, 8·1, 7·1, 6·2, 5·5, 4·8 (Intermediate gear).
4·2, 3·7, 3·2, 2·8, 2·5, 2·2, 1·9, 1·7 (Full gear).

N.B.—It may be noted here that all the toothed wheels used in the machine are machine-cut, ensuring smooth running and a high efficiency in the transmission of the motion. In most cases the pitch of the teeth is expressed in terms of n teeth per diametral inch, and then the height of the tooth above the pitch line is $\frac{1}{n}$ inches.

EXERCISES.

1.—**Bracket for Pinion Shaft.** Draw the two views given in Fig. 3, and add an elevation to the left of the given one. *Scale, ½ full size.*

2.—**Bracket for Main Shaft.** Draw the two given views and an additional elevation. *Scale, ½ full size.*

3.—**Chain Wheel Case.** Draw the front elevation and plan, and add a side elevation to the right of the front elevation. *Scale, ½ full size.*

4.*—**Gearing and Brackets.** Draw the two given views, Figs. 1 and 2, and add an elevation to the left of Fig. 1. Indicate the bevel wheels by their pitch surfaces, except when shown in section. *Scale, 3 ins. = 1 foot.*

* This Exercise is intended for Advanced Students.

48-INCH BORING AND TURNING MILL.

DETAILS OF GEARING ATTACHED TO BED.

Scale 2"=1 Foot.

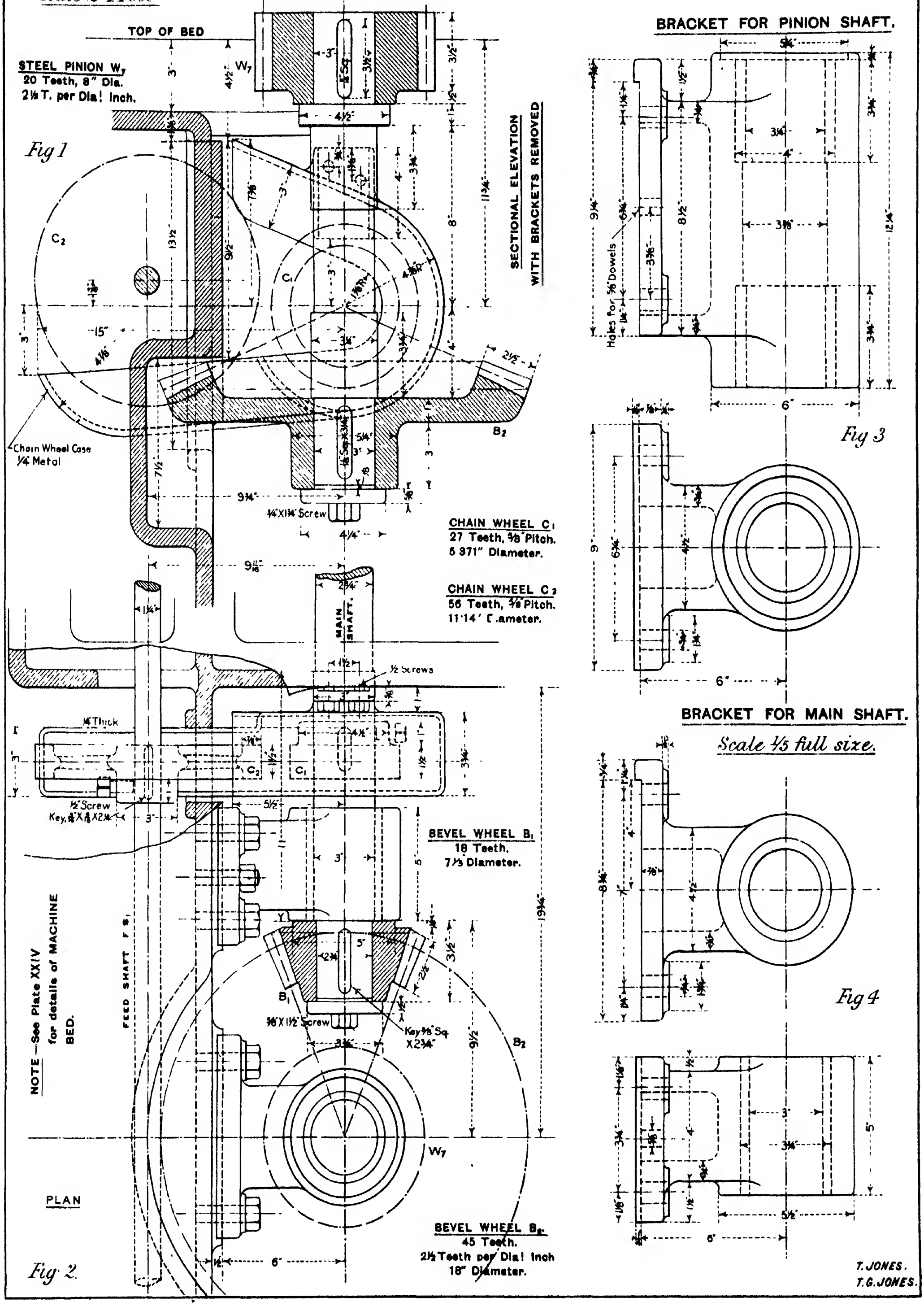


Plate XXVII.—BORING AND TURNING MILL.

GEARING FOR MAIN DRIVING SHAFT.—All the power necessary for the driving of the machine passes through the pulley and spur wheel gearing detailed in Fig. 2.

The four-speed pulley—which is connected with an equal one on the counter-shaft—is carried on the main shaft, and has keyed to it the pinion W_1 and the wheel W_3. The large wheel W_6, keyed to the shaft, butts against the pulley, and, as is usual, can be connected to the latter by an adjustable bolt. The two ends of the pulley are brass-bushed.

The back gearing is such that two rates of reduction of speed may be effected. On the long cast-iron sleeve of the back shaft are the pinion W_5—cast with the bush—and the two wheels W_2, W_4, which are movable together through a distance of 2⅝" along a feather key. The cast-iron ends of the back shaft are bored eccentrically ⅜"; one is supported in a long boss projecting from the side of the machine bed, and the other, to which a handle is fixed for the purpose of throwing the wheels in and out of gear—see Figs. 3 and 4—is carried by the horizontal arm formed on the bracket for the outer end of the main shaft. This shaft support is secured to a separate base of ⊓ section which is fixed to the machine bed by eight ¾" screws.

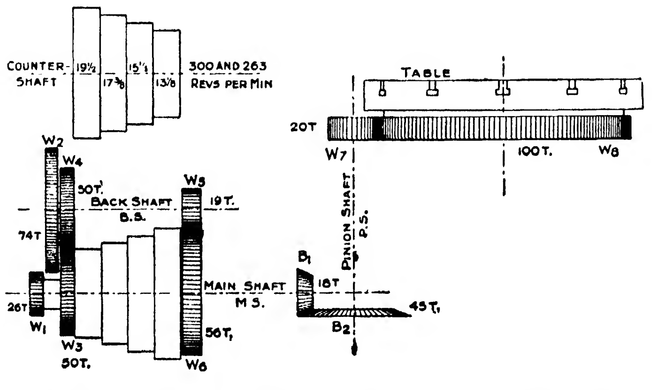
The greater reduction of speed by the back gearing is effected when the wheel W_2 is moved into gear with the pinion W_1, and for the intermediate gear the wheels are in the positions shown on the drawing.

EXERCISES.

1.—**Base.** Draw the front elevation, the plan, and the end elevation projected to the right of the plan. *Scale, ¼ full size.*

2.—**Bracket.** Draw two elevations and a plan, showing the eccentric handle for the back shaft. *Scale, 6 ins. = 1 foot.*

3.*—**Gearing, &c.** Draw the given sectional plan, and add a front elevation. Add also an end elevation to the right of the plan, indicating the wheels by their pitch circles. *Scale, 3 ins. = 1 foot.*



Calculation of Speeds of the Driving Shaft.—The accompanying figure represents diagrammatically the gearing from the counter-shaft to the table. The counter-shaft may be run at 300 and 263 revolutions per minute, and the diameters of the cone pulleys are 19½", 17¾", 15¼", and 13¼", respectively.

There are three possible arrangements, viz.: (*a*) **Single Gear,** when the pulley is locked to the wheel W_6 and so rotates the shaft directly; (*b*) **Intermediate Gear,** when the motion of the pulley is transmitted through W_3 and W_4 to the back shaft, and thence to the machine shaft **MS** through W_5 and W_6; (*c*) **Full Gear,** when the motion is transmitted through W_1, W_2, and W_5, W_6.

Since the pulley has four different diameters, there are four possible speeds for each gear for each speed of the counter-shaft; therefore, in all, there are 24 possible speeds of the main shaft

[*Continued on Plate XXVIII.*

* This Exercise is intended for Advanced Students.

48-INCH BORING AND TURNING MILL.

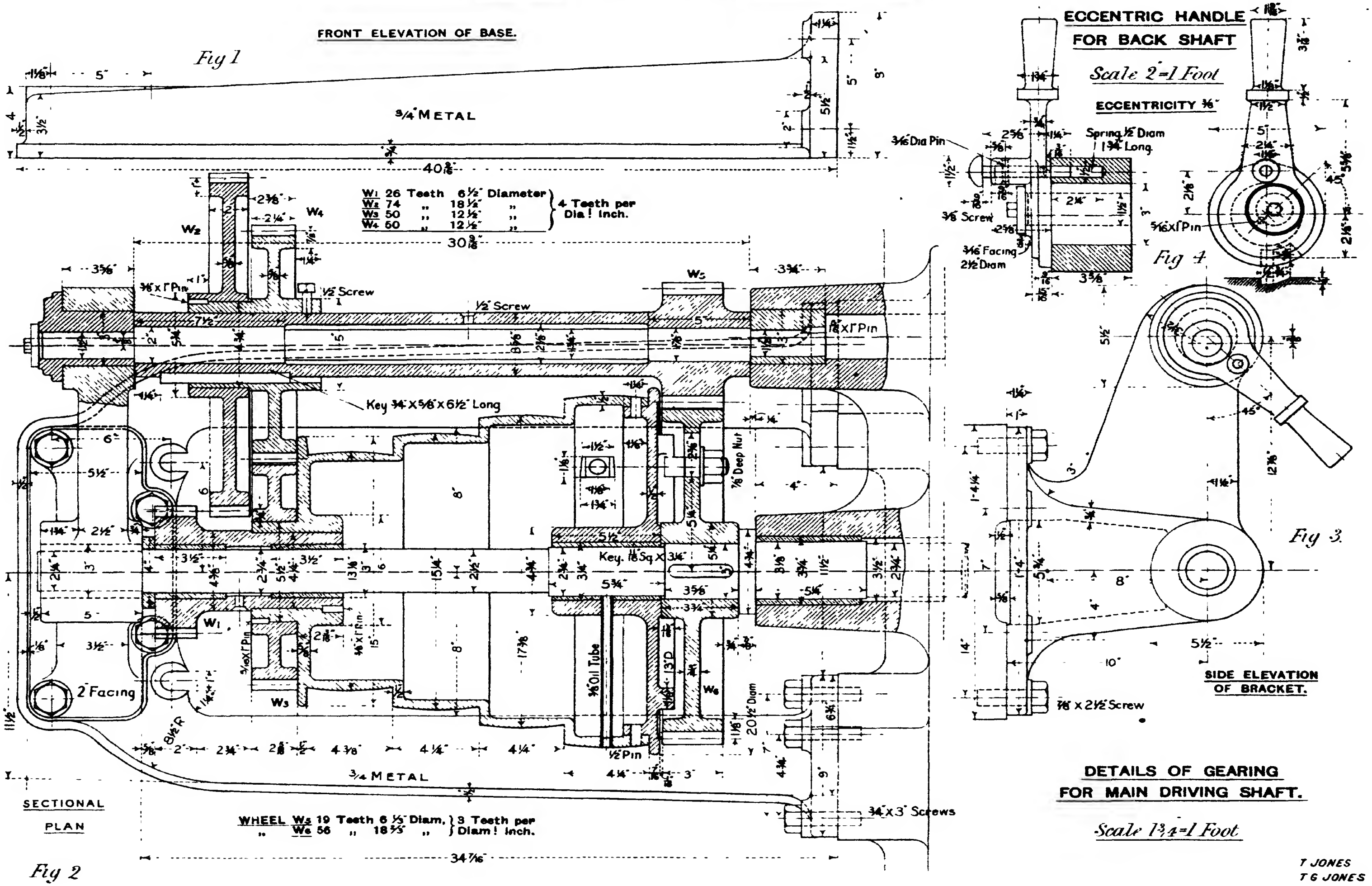


Plate XXVIII.—BORING AND TURNING MILL.

RIGHT-HAND STANDARD.—The two standards required for the supporting and guiding of the cross slide are alike, but, of course, of opposite hands.

Each is of box section, $\frac{5}{8}''$ metal, and is rendered lighter by the three large holes passing through it. The base is $35''$ long $\times\ 8\frac{1}{2}''$ wide, and is fixed to the planed top of the bed by five $\frac{7}{8}''$ screws. It will be seen on reference to Plate XXIV. that the face on the bed is $\frac{1}{2}''$ narrower than the base of the standard, so that the long edges of the latter project $\frac{1}{4}''$ on each side of the facing. The two standards are stayed together at the top by the cross stay—detailed on Plate XXIX.—which is attached to them at the facings, $12'' \times 5\frac{1}{4}''$, by $\frac{5}{8}''$ screws.

The vertical face, over which the cross slide moves, is $6\frac{3}{4}''$ wide, with square edges, and between the two inside edges moves the nut attached to the slide. For the introduction of the clamping piece of the slide the distance between the inside edges is increased at the top and the bottom of the vertical face.

As shown on Plate XXXI. the feed screw hangs from the top of the standard, and is actuated automatically from the counter-shaft, through pulleys and toothed wheels, for the rapid vertical movement of the cross slide.

EXERCISES.

1.*—**R. H. Standard.** Draw the two given elevations, the sectional plan, and a complete outside plan. *Scale, 2 ins. = 1 foot.*

2.*—**L. H. Standard.** Draw the views as mentioned above. *Scale, 2 ins. = 1 foot.*

CALCULATION OF SPEEDS OF THE DRIVING SHAFT.—*Continued.*

(*a*) **Single Gear**:—

Speed of Counter-shaft.	300 per Min.	263 per Min.
Maximum speed	$\frac{300 \times 19\frac{1}{2}}{13\frac{1}{8}} = 446$	$\frac{263 \times 19\frac{1}{2}}{13\frac{1}{8}} = 391$
1st Intermediate speed	$\frac{300 \times 17\frac{3}{8}}{15\frac{1}{4}} = 342$	$\frac{263 \times 17\frac{3}{8}}{15\frac{1}{4}} = 300$
2nd Intermediate speed	$\frac{300 \times 15\frac{1}{4}}{17\frac{3}{8}} = 263$	$\frac{263 \times 15\frac{1}{4}}{17\frac{3}{8}} = 231$
Minimum speed	$\frac{300 \times 13\frac{1}{8}}{19\frac{1}{2}} = 202$	$\frac{263 \times 13\frac{1}{8}}{19\frac{1}{2}} = 177$

[*Continued on Plate XXIX.*

* These Exercises are intended for **Advanced** Students.

48-INCH BORING AND TURNING MILL.

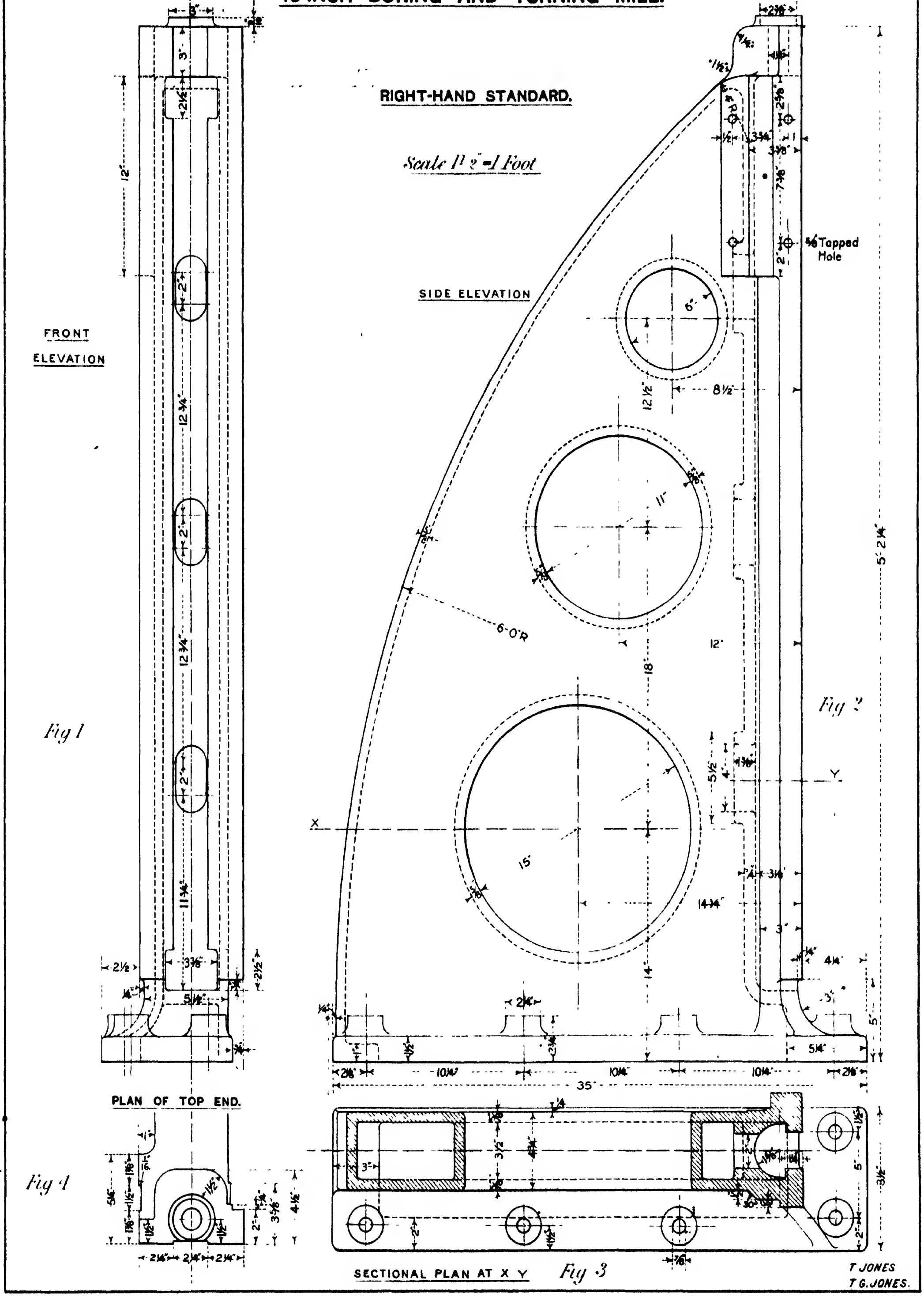


Plate XXIX.—BORING AND TURNING MILL.

CROSS STAY.—The cross stay, Figs. 1, 2 and 3, connects together the two standards, and so makes the upper portion of the machine rigid. The casting is curved and of box section, ½″ thick, stiffened by three transverse webs, and the ends are flanged forward to provide sufficient bearing area against the standards. The top is also carried forward, at a thickness of ¾″, to a straight edge which lies ¼″ behind the vertical faces of the standards when the stay is in position. Each end is secured to the corresponding standard by four ⅝″ screws.

As previously mentioned the cross slide is moved along the faces of the standards by the simultaneous rotation of the screws supporting it; and the brackets for the support of the horizontal shaft connecting the two screws through bevel wheels (see Plate XXXI.) are carried by the stay. These **brackets** are detailed in Figs. 4 and 5: the right-hand one is fixed by three ⅝″ screws passing through plain holes in its base; while the other, which is extended backwards to give support to the elevating lever and short pulley shaft, is secured by four screws passing upwards through the top of the stay into the base of the bracket. Of the four screws used for the latter bracket, the heads of the three which would be seen from the front of the machine are made cylindrical to fit into recesses.

EXERCISES.

1.—**Brackets for Stay.** Draw two elevations and a plan of each of the brackets. *Scale, ¾ full size.*

2.—**Cross Stay.** Draw the three given views, and add an end elevation projected from the plan to the left. *Scale, 3 ins. = 1 foot.*

3.*—**Cross Stay and Brackets.** Draw two elevations and a plan, showing the brackets in position on the stay. *Scale, 3 ins. = 1 foot.*

4.*—**Machine Bed, Standards and Cross Stay.** Draw two elevations and a plan, showing the several parts connected together. *Scale, 1½ ins. = 1 foot.*

CALCULATION OF SPEEDS OF THE DRIVING SHAFT.—*Continued.*

(*b*) **Intermediate Gear.**—Motion transmitted through W_3, W_4 and W_5, W_6.

$$\text{Speed of shaft} = \text{speed of pulley} \times \frac{W_3 \times W_5}{W_4 \times W_6}$$

$$= \quad ,, \quad ,, \times \frac{19}{56}$$

Speed of Counter-Shaft.	300 per Min.	263 per Min.
Maximum speed ...	$\frac{446 \times 19}{56} = 151$	$\frac{391 \times 19}{56} = 132{\cdot}6$
1st Intermediate speed ...	$\frac{342 \times 19}{56} = 116$	$\frac{300 \times 19}{56} = 102$
2nd Intermediate speed ...	$\frac{263 \times 19}{56} = 89{\cdot}5$	$\frac{231 \times 19}{56} = 78{\cdot}5$
Minimum speed ...	$\frac{202 \times 19}{56} = 68{\cdot}5$	$\frac{177 \times 19}{56} = 60$

[*Continued on Plate XXX.*

* These Exercises are intended for Advanced Students.

48-INCH BORING AND TURNING MILL.

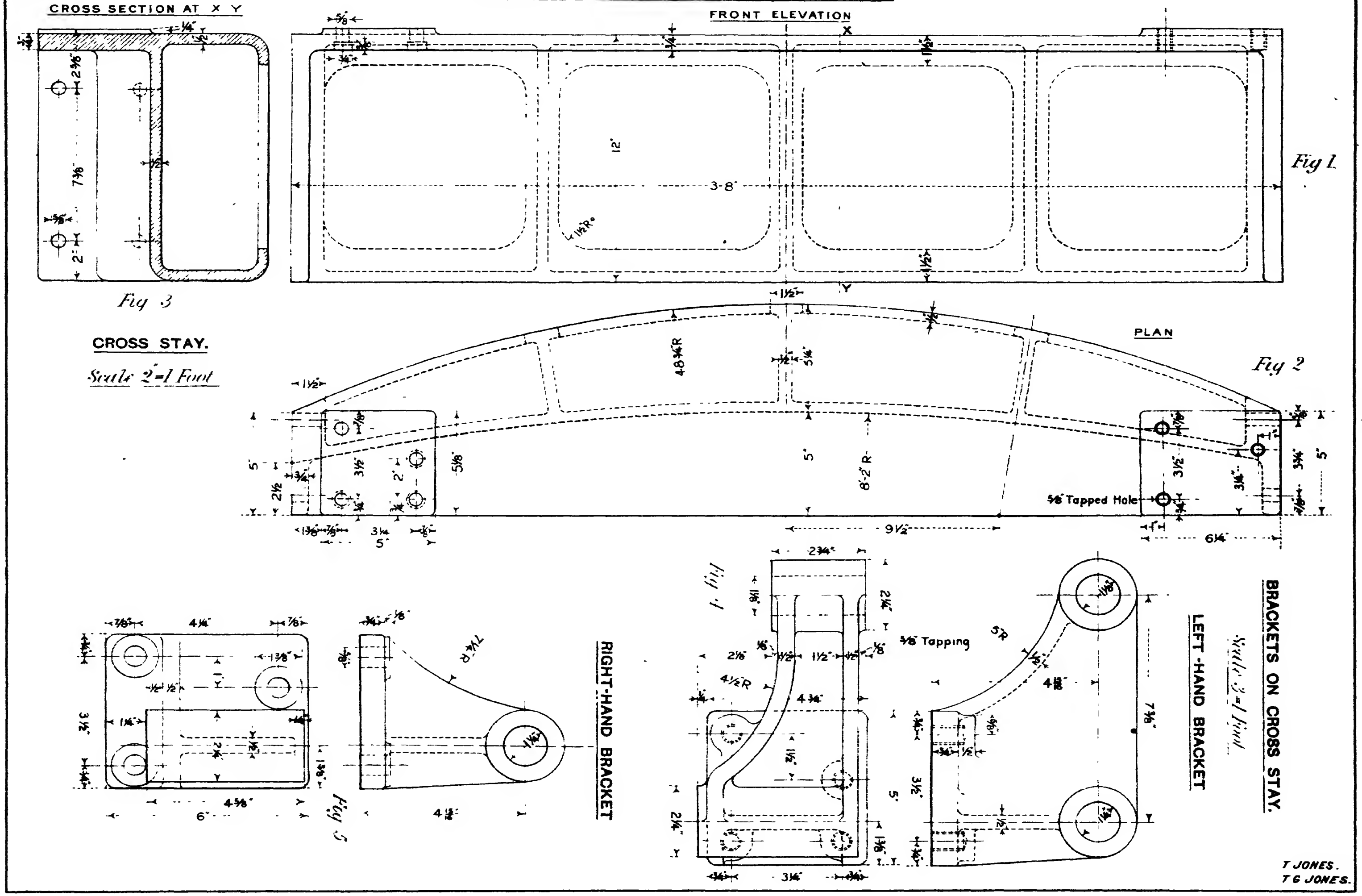


Plate XXX.—BORING AND TURNING MILL.

CROSS SLIDE.—The cross slide has a total length of 7'—6", and a width of 16¾", and the parts which bear against the standards are extended vertically to ensure rigidity. The slide is of a uniform ⊏ section with upper and lower square-edged flanges over which the two saddles move; and the portion between the standards is stiffened considerably, to resist the bending due to the pressure on the tools, by a curved back of box section. Each face bearing against the standard is 28" long × 6¾" wide.

The nuts used for the vertical movement of the slide are detailed in Fig. 6. For the purpose of relieving the supporting screws the slide may be clamped against the standards by tightening up the clamping pieces—shown in Figs. 2 and 4. Each clamp is bored out to 1¼" diameter for the easy passage through it of the screw.

Since each saddle with a tool bar is actuated independently of the other, it is necessary to duplicate the feed shaft and feed screw. Supports for them are provided at the ends of the slide. The two feed shafts—detailed on Plate XXXII.—are placed highest in the slide, and in the same straight line, their inner ends being supported by the same piece near the centre of length of the slide. Below these shafts are:—first, the feed screw for the right-hand saddle, which extends almost to the centre of the slide; and then the feed screw for the other saddle which runs the whole length of the slide.

The adjustable stop, detailed in Fig. 5, is for the purpose of setting the left-hand tool bar exactly central with the table.

The feed shafts and screws receive their motion through the two sets of feed gearing—detailed on Plate XXXVIII.—which are fixed on the back of the slide as shown in Fig. 3.

EXERCISES.

1.*—**Cross Slide.** Draw the complete front elevation, the plan and the sectional end elevation, and add an end elevation to the left of the front elevation. Show the supports for the screws and shafts and the nuts and clamping pieces. *Scale, 2 ins. = 1 foot.*

2.*—**Cross Slide, Standards, Cross Stay and Bed.** Draw the front elevation and plan of these parts connected together. *Scale, 1½ ins. = 1 foot.*

CALCULATION OF SPEEDS OF THE DRIVING SHAFT.—*Continued.*

(c) **Full Gear.**—Motion is transmitted through W_1, W_2 and W_5, W_6.

$$\therefore \text{Speed of shaft} = \text{speed of pulley} \times \frac{W_1 \times W_5}{W_2 \times W_6}$$

$$= \quad ,, \quad ,, \quad \times \frac{26 \times 19}{74 \times 56}$$

$$= \frac{\text{speed of pulley}}{8{\cdot}388}$$

Speed of Counter-shaft.	300 per Min	263 per Min.
Maximum speed	$\frac{446}{8{\cdot}388} = 53{\cdot}2$	$\frac{391}{8{\cdot}388} = 46{\cdot}6$
1st Intermediate speed	$\frac{342}{8{\cdot}388} = 40{\cdot}7$	$\frac{300}{8{\cdot}388} = 35{\cdot}7$
2nd Intermediate speed	$\frac{263}{8{\cdot}388} = 31{\cdot}4$	$\frac{231}{8{\cdot}388} = 27{\cdot}8$
Minimum speed	$\frac{202}{8{\cdot}388} = 24$	$\frac{177}{8{\cdot}388} = 21{\cdot}1$

Velocity of Driving Belt.—The belt is moving at its $\left\{\begin{matrix}\text{max.}\\ \text{min.}\end{matrix}\right\}$ velocity when on the $\left\{\begin{matrix}19\frac{1}{2}\\ 13\frac{1}{4}\end{matrix}\right\}$ diameter pulley on the counter-shaft running at $\left\{\begin{matrix}300\\ 263\end{matrix}\right\}$ revolutions per minute.

$$\text{Maximum velocity} = \frac{19\frac{1}{2} \times \pi \times 300}{12} = 1531 \text{ ft. per minute.}$$

$$\text{Minimum velocity} = \frac{13\frac{1}{4} \times \pi \times 263}{12} = 903{\cdot}5 \text{ ft. per minute.}$$

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* These Exercises are intended for Advanced Students.

48-INCH BORING AND TURNING MILL.

CROSS SLIDE.

PLATE XXX.

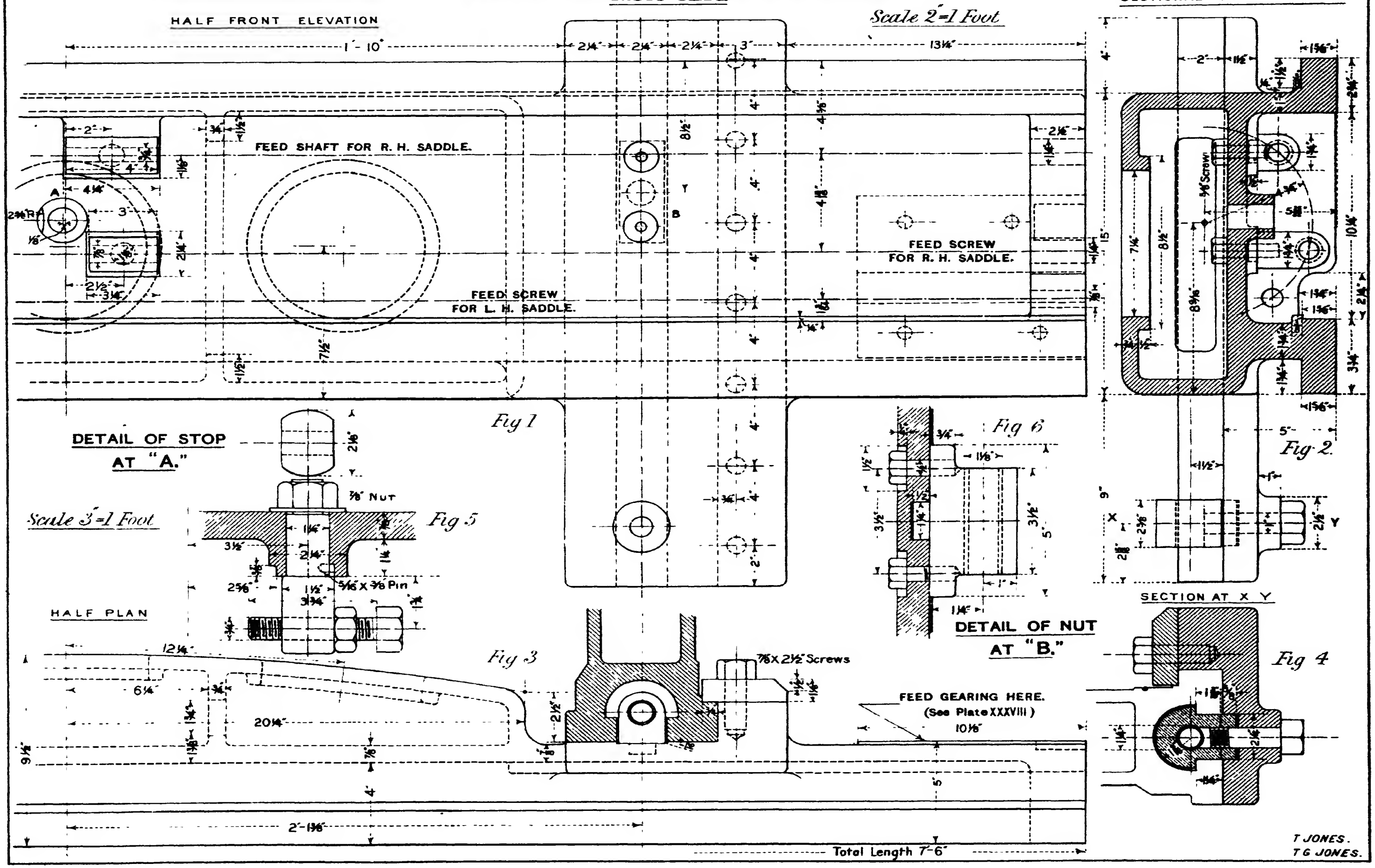

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Plate XXXI.—BORING AND TURNING MILL.

ELEVATING MOTION FOR CROSS SLIDE.—Since, during the boring or turning work, the cross slide is stationary, and all the necessary vertical motion of the tool is secured by the movement of the tool bar across the swivel slide, it is an advantage to move the cross slide as quickly as possible along the uprights when setting the machine.

Fixed between a bracket bolted to the outside of the left-hand standard and the L.H. bracket bolted to the cross stay is a spindle on which can rotate a cast-iron sleeve. On the outer end of the sleeve is keyed a 9″ pulley, driven from the counter-shaft by a pulley 18″ diameter, and at the other end is cast a pinion P_1, having 24 teeth. (Attention is drawn to the method of lubricating the sleeve by felt pads, supplied with oil through the hole running along the centre of the spindle.) The cast-iron elevating lever is centred at one end of the spindle, and carries two equal pinions P_2, P_3 in gear; P_2 is also in gear with the pinion P_1 on the sleeve.

The bevel wheels B_4, B_3 connect the vertical screws in the standards with the horizontal shaft above the cross stay; and keyed to the boss of the left-hand wheel B_3 is the spur wheel W_9. The elevating lever passes down by the side of the standard, and its end is movable over a curved stop sector, which enables the lever to be held in any one of three positions. For the position shown in the drawing, Fig. 2, the wheel W_9 is not in gear with either of the pinions P_2, P_3, and consequently the cross slide is not moved; but, by putting the lever in one or other of the "in gear" positions, the motion of the elevating pulley is transmitted to the screws and the slide is raised or lowered according as one or other of the pinions is in gear with W_9. The method of pinning the lever to the stop sector is shown in Fig. 5.

Since the bevel wheels B_4, B_4, rotate in opposite directions it is necessary to have one elevating screw R.H. and the other L.H. (See Plate XXXII. for details of screws.)

MOVEMENT OF THE CROSS SLIDE.

$$\text{Movement of slide} = \text{revolutions of counter-shaft per minute} \times \frac{18}{9} \times \frac{P_1}{W_9} \times \frac{B_3}{B_4} \times \text{pitch of screws}$$

$$= \quad " \quad " \quad " \quad " \quad \times \frac{18}{9} \times \frac{24}{48} \times \frac{18}{36} \times \frac{1}{4}$$

$$= \frac{\text{revolutions of counter-shaft per minute}}{8} \text{ inches per minute.}$$

$$= \frac{300}{8} \text{ or } \frac{263}{8}$$

$$= 37\tfrac{1}{2} \text{ inches or } 32\tfrac{7}{8} \text{ inches per minute.}$$

EXERCISES.

1.—**Bracket of L.H. Standard.** Draw two elevations and a plan. *Scale, $\frac{3}{4}$ full size.*

2.—**Elevating Lever and Stop Sector.** Draw two elevations and a plan, indicating in the side elevation the pinions by their pitch circles. *Scale, $\frac{3}{8}$ full size.*

3.*—**Complete Elevating Gear.** Draw and complete the three given views. *Scale, 4 ins. = 1 foot.*

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* This Exercise is intended for Advanced Students.

48-INCH BORING AND TURNING MILL.

ELEVATING MOTION FOR CROSS SLIDE.

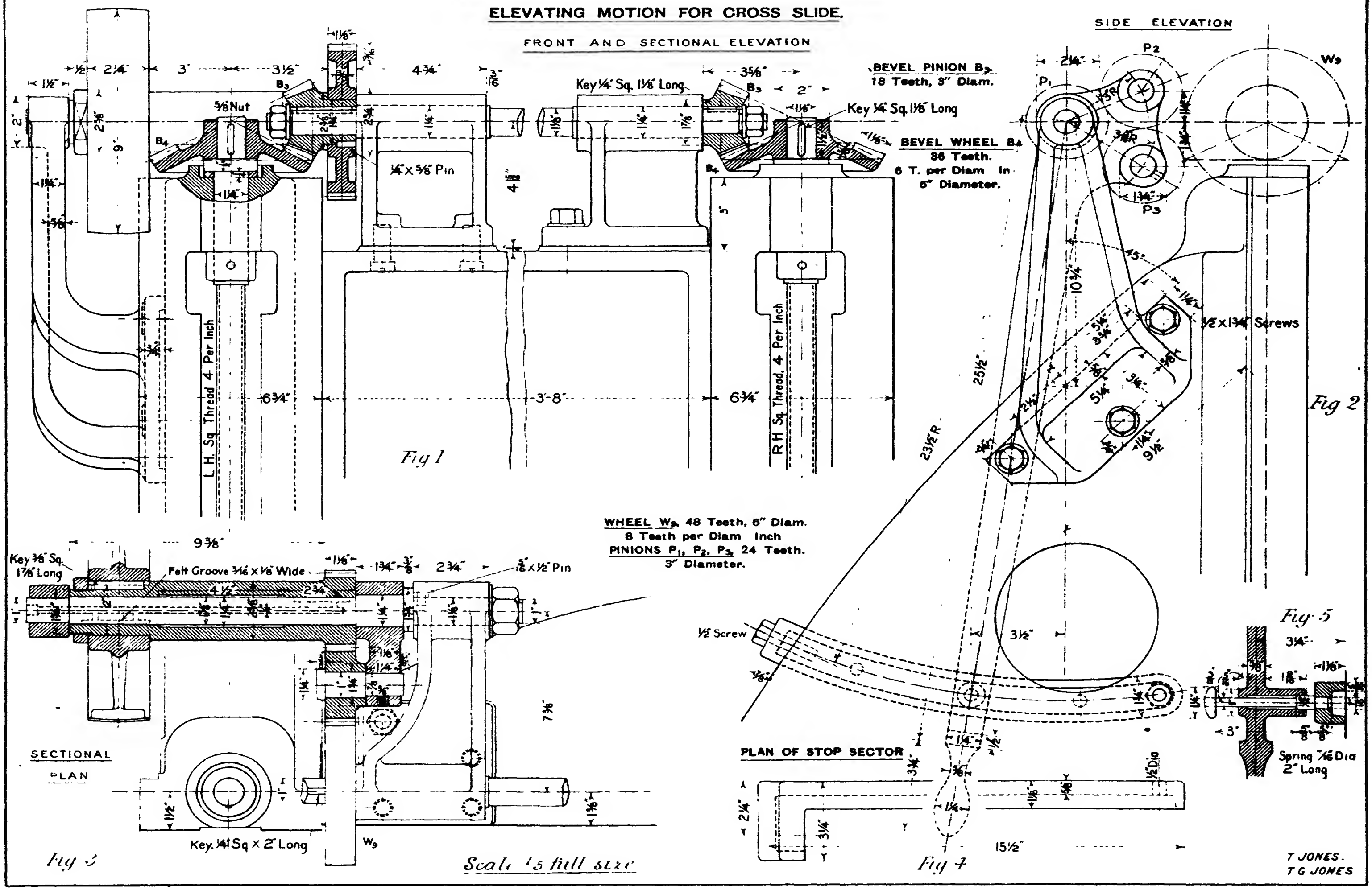


Plate XXXII.—BORING AND TURNING MILL.

FEED SHAFTS FOR SADDLES.—As shown in Plate XXX. the two feed shafts are in the same line, and extend the whole length of the cross slide. The outer end of each is supported by one or other end of the slide; and the smaller ends are carried in a bearing, which is placed 2" to the right of the centre of length of the slide—the longer shaft is therefore for the left-hand saddle. The shaft end, carried by the end of the slide, is held endways by a shoulder on one side and a thick washer and two steel lock nuts on the other—as detailed in the last drawing on the plate.

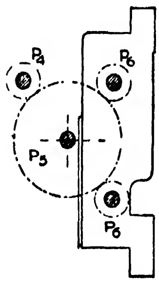
For the purpose of throwing the shaft in or out of gear with the wheel P_5, driven from the feed gearing at the back of the slide, there is a sliding pinion P_6 on the shaft end, and when out of gear the pinion is held by a small plunger.

Extending almost the whole length of the shaft is a keyway, ¼" wide × ⅛" deep, in which slides the key of the worm B, carried by the saddle. (See Plates XXXV. and XXXVI.) The motion of the worm is transmitted to the rack pinion which actuates the tool bar; and hence the motion of the feed shaft determines the down feed of the tool. Each shaft may be rotated by means of a handle placed on the square end of the shaft.

FEED SCREWS FOR SADDLES.—The two screws are in most respects alike; but, whereas the one for the R.H. saddle extends only half the length of the slide, the other extends the whole length, and has a separate piece fixed on the R.H. end, so that it may be turned by hand from this side of the machine. These screws are used for giving the cross motion to the saddles and tool bars, and they are automatically driven through sliding pinions P_6 from the wheel P_5.

FEED SCREWS FOR CROSS SLIDE.—As previously explained, these screws hang from the tops of the standards, and support the cross slide. They are driven simultaneously by bevel gearing when required to raise or lower the slide. (See Plate XXXI. for details of elevating gear.)

ROTATION OF FEED SHAFTS AND SCREWS.—Each shaft and screw may be connected through the change wheel P_5 with the pinion P_4 of the feed gear by the sliding pinion P_6.



The arrangement is shown in the accompanying diagram. Now all the feed motions are derived from the feed gear box at the side of the machine bed, and the gearing in it is such that four rates of motion—relative to the speed of the table—may be given to the vertical feed shaft which actuates the feed gearing on the cross slide. This latter gearing gives three rates of motion for each speed of the vertical shaft, and hence the pinion P_4 is capable of running at twelve different speeds relative to the speed of the table. Since the pinions P_6 are the same size as the driving pinion P_4, the shafts and screws will rotate at the same rate as P_4.

The calculations for the twelve speeds are given in the notes to Plates XXXIII. and XXXIV., and it will be seen that they are:—3·15, 2·18, 1·68, 1·33, 1·16, 0·92, 0·71, 0·49, 0·38, 0·26, 0·16, 0·11 revolutions for one revolution of the table.

EXERCISES.

1.—**Feed Shafts.** Draw three elevations of one or other of the shafts, showing the pinion P_6 and the bearing for the small end. *Scale, ½ full size.*

2.—**Feed Screws.** Draw one elevation of each screw, showing the sliding pinions in the "out of gear" positions. *Scale, ½ full size.*

3.—**Screws for Cross Slide.** Draw an elevation of one screw, showing the bevel wheel on its end, and at least 6" of screw. *Scale ¾ full size.*

4.*—**Cross Slide with Shafts and Screws.** Draw the front elevation, end elevation, and plan of the slide showing the shafts, screws, pinions and bearings in position. *Scale, 2 ins. = 1 foot.*

* This Exercise is intended for Advanced Students.

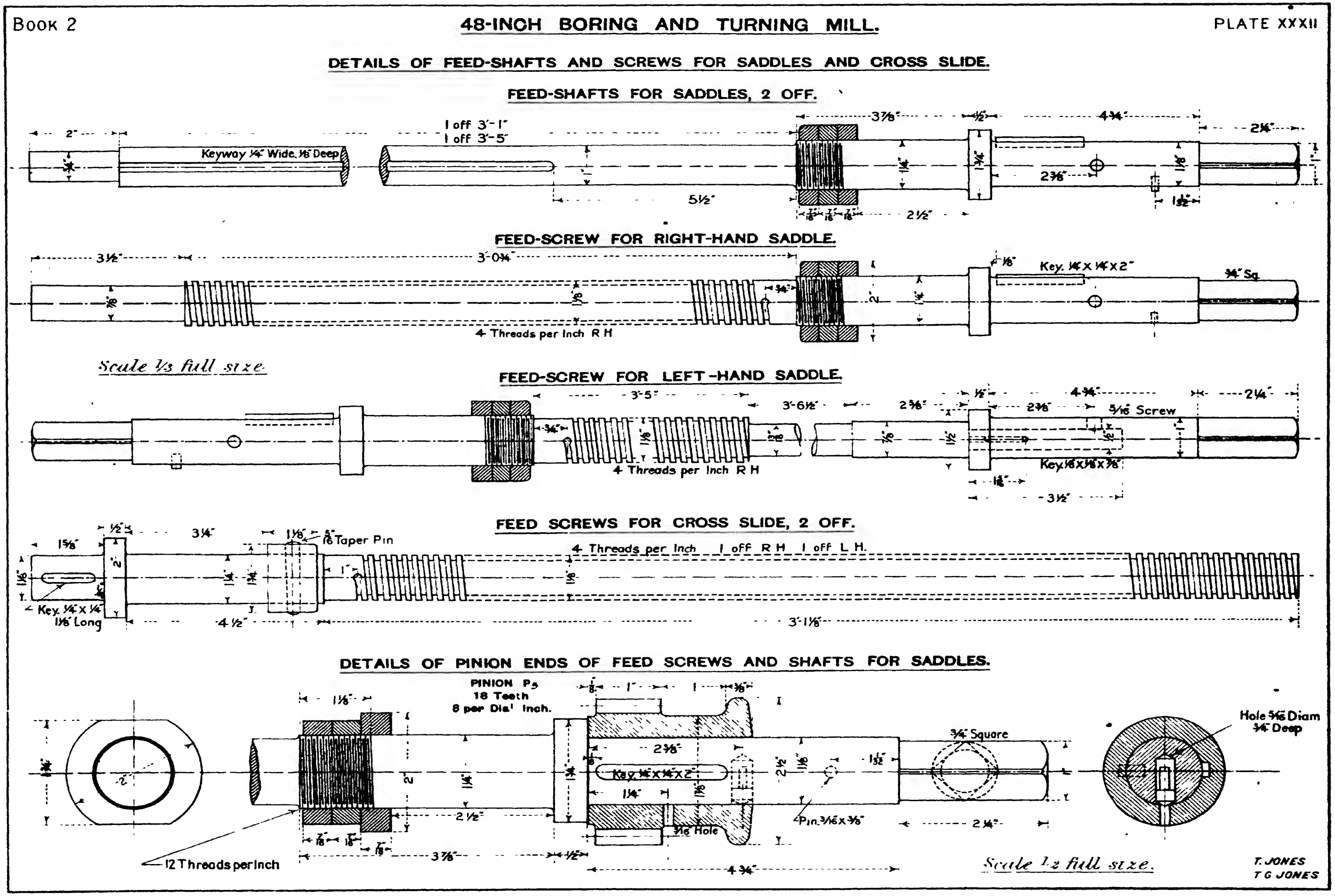

Book 2
48-INCH BORING AND TURNING MILL.
PLATE XXXII
DETAILS OF FEED-SHAFTS AND SCREWS FOR SADDLES AND CROSS SLIDE.
FEED-SHAFTS FOR SADDLES, 2 OFF.
1 off 3'-1"
1 off 3'-5"
Keyway ¼" Wide, ⅛" Deep
FEED-SCREW FOR RIGHT-HAND SADDLE.
Key ¼" x ¼" x 2"
¾" Sq.
4 Threads per Inch R H
Scale ⅓ full size.
FEED-SCREW FOR LEFT-HAND SADDLE.
5/16 Screw
4 Threads per Inch R H
FEED SCREWS FOR CROSS SLIDE, 2 OFF.
4 Threads per Inch 1 off R H 1 off L H.
Taper Pin
Key ¼" x ¼"
1⅛" Long
DETAILS OF PINION ENDS OF FEED SCREWS AND SHAFTS FOR SADDLES.
PINION P5
18 Teeth
8 per Dia' Inch.
¾" Square
Hole 5/16 Diam
¾" Deep
Key ¼" x ¼" x 2"
Pin 3/16 x ⅜"
5/16 Hole
12 Threads per Inch
Scale ½ full size.
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Plate XXXIII.—BORING AND TURNING MILL.

LEFT-HAND FEED GEAR BOX.—These drawings represent the box containing the patent feed gear for producing four rates of rotation of the vertical feed shaft per revolution of the table. Since there are two saddles and tool bars to be worked independently of each other it is necessary to have two complete sets of the feeding gear, and the one illustrated is used in connection with the left-hand saddle.

The box is fixed by four ⅝" screws to the side of the machine bed, and about half of it goes into the recess shown in the drawing of the bed on Plate XXIV. The feed shaft which drives the gearing runs across the bed, and enters the box by the bearing fixed at "XX."

The cover is bossed out to furnish a bearing for one end of the tumbler bracket, and is also made with a cylindrical extension to make room for the accommodation of the reversing bevel gearing. This portion of the cover has itself a cover which supports one end of the horizontal gear spindle. The vertical feed shaft passes out of the box through a brass-bushed bearing, whose upper end is enlarged to receive the collar which takes up the weight of the shaft. A raw hide washer is interposed between the rubbing surfaces, and the collar is protected by a lid, so that the space surrounding it may be filled with clean oil.

The operating handle is fixed to the end of the tumbler bracket, and at the centre it is formed with an extended edge, to which is fixed a brass-graduated segment. By turning the handle through about ⅓rd of a revolution the full number of changes (four) can be made.

Between any two positions of the lever for giving a feed is a position where the feed motion is stopped; and in any of these positions the handle and tumbler bracket are held securely by a plug—shown in Figs. 2 and 3—which can be pulled outwards, and by a quarter of a turn held so, while the operating handle is being moved round.

To ensure the smooth running of the gearing the lower portion of the box contains oil, which is passed in through a small oil box, and may be drawn off through the tap at the bottom.

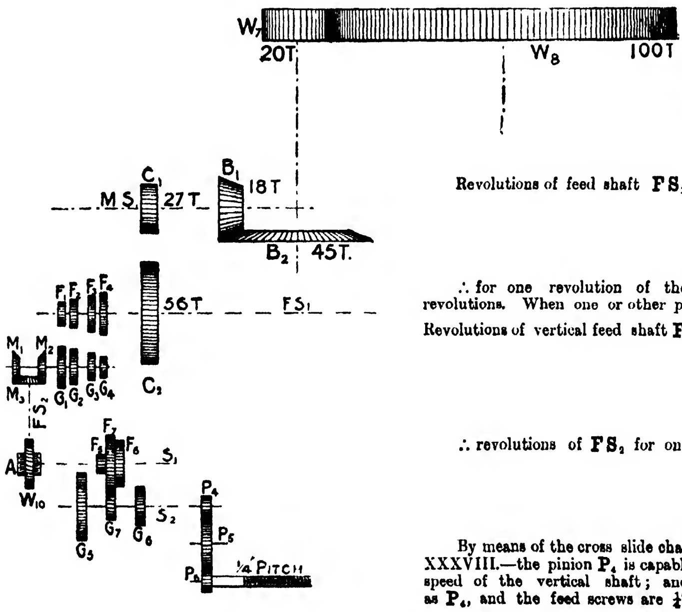
The fork of the double-ended claw clutch, for the stopping, starting and reversing of the motion of the vertical feed shaft, is keyed to the short horizontal shaft, to one end of which is pinned the arm for operating the clutch. In the position shown in Fig. 2 the arm is in the intermediate position, and the clutch is out of gear.

EXERCISES.

1.*—**Details of Feed Gear Box.** Draw the sectional elevation (showing the bearing for the feed shaft), the front elevation and plan of the box without the covers, omitting the horizontal gear shaft. *Scale, 6 ins. = 1 foot.*

2.*—**Covers for Gear Box.** Draw the front elevation, the sectional side and side elevations, and a plan projected from the front elevation. *Scale, 6 ins. = 1 foot.*

3.*—**Feed Gear Box.** Draw the two given elevations, showing the bearing for feed shaft, and add a plan projected from the front elevation, and a sectional plan, through the centre-line of the feed shaft, projected from the sectional side elevation. *Scale, ⅜ full size.*



Calculation of Feed Motions.—The gearing connecting the table with the feed shafts and screws for actuating the tools is represented diagrammatically in the accompanying figure; and it is required to express the various amounts of cross feed and down feed of the tool per revolution of the table.

$$\text{Revolutions of feed shaft } \mathbf{FS_1} = \text{revolutions of table} \times \frac{W_8 \times B_2 \times C_1}{W_7 \times B_1 \times C_2}$$

$$= \quad ,, \quad \times \frac{100 \times 45 \times 27}{20 \times 18 \times 56}$$

$$= \quad ,, \quad \times 6\tfrac{3}{112}$$

∴ for one revolution of the table the feed shaft $\mathbf{FS_1}$ makes $6\frac{3}{112}$ revolutions. When one or other pair of wheels **F**, **G**, is in gear:—

$$\text{Revolutions of vertical feed shaft } \mathbf{FS_2} = \text{revolutions of wheel shaft } \mathbf{FS_1} \times \frac{F}{G}.$$

$$\therefore \text{ revolutions of } \mathbf{FS_2} \text{ for one revolution of table} = \begin{cases} \frac{675}{112} \times \frac{37}{20} = 11{\cdot}15 \\ \frac{675}{112} \times \frac{32}{25} = 7{\cdot}71 \\ \frac{675}{112} \times \frac{25}{32} = 4{\cdot}71 \\ \frac{675}{112} \times \frac{20}{37} = 3{\cdot}26 \end{cases}$$

By means of the cross slide change gearing—explained in the notes to Plate XXXVIII.—the pinion P_4 is capable of running at three different speeds for each speed of the vertical shaft; and since the pinions P_6 are the same size as P_4, and the feed screws are ¼" pitch—

[*Continued on Plate XXXIV.*

* These Exercises are intended for Advanced Students.

48-INCH BORING AND TURNING MILL.

LEFT-HAND FEED GEAR BOX.

Scale 3¼" = 1 Foot

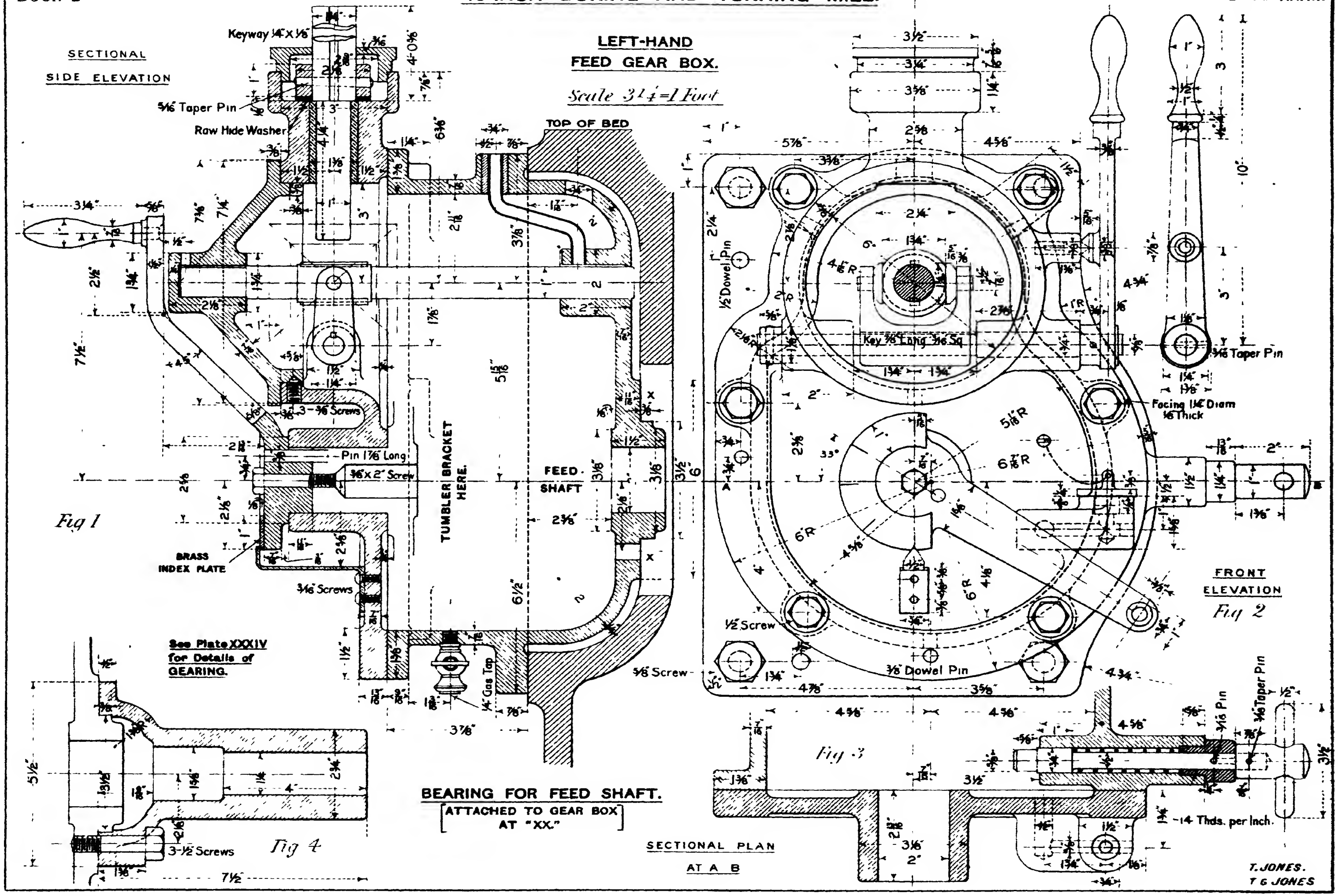


Plate XXXIV.—BORING AND TURNING MILL.

GEARING FOR FEED GEAR BOX.—In this patent feed gear box there are two sets of spur wheels used: the first set is carried by the tumbler bracket, and the other by the short horizontal shaft directly above, from which the vertical feed shaft receives its motion.

The tumbler bracket is a hollow cylindrical casting with cylindrical ends supported in bearings formed in the body and the cover of the box respectively, and extends the whole depth of the box so that no end motion is possible. The feed shaft enters the tumbler from the back of the box, and is supported by the two hollow ends of the tumbler, and by the bracket, detailed in Fig. 4, Plate XXXIII. There are four wheels, F_1, F_2, F_3, F_4, mounted on the feed shaft within the tumbler: the three wheels, F_2, F_3, F_4, being forced on and keyed to the prolonged boss of the wheel F_1, which is itself keyed to the shaft. Each of these wheels is in gear with one of the four pinions A, B, C, D, mounted on the circumference of the tumbler; so that, by a slight rotation, any wheel F on the feed shaft may be connected with the corresponding wheel G by means of its pinion. The sum of the diameters of the four pairs of wheels is constant, so that, when motion is being transmitted through any pair, the connecting pinion is directly between them.

The motion from the horizontal to the vertical shaft is transmitted through the mitre wheels M_1, M_2, M_3, the first two mentioned being loose on the horizontal shaft. On the inner face of each of the wheels M_1, M_2 are six radial claws which may be put in gear with the claws on the steel clutch between them. When the reversing lever—see Plate XXXIII.—is moved, the clutch slides over two feather keys in the shaft, and so one or other of the wheels transmits the motion to the vertical shaft. For the position of the clutch shown in Fig. 1 the vertical feed shaft would be stationary.

To limit the rotation of the tumbler bracket to the required amount there are two stop pins: these are placed one at each end of the segment containing the holes for holding the bracket, by the plug, in any of its seven positions—four positions, for each of which a pair of wheels, F, G, are in gear, and three out-of-gear positions. It is evident then that the vertical feed shaft may be stopped and started at two positions of the gear box.

The vertical shaft has a keyway along its whole length, and is of such a length that, for any position of the cross slide which carries a second feed gear arrangement, the feed motion may be transmitted to the worm A—see Plate XXXVIII.—for further modification.

EXERCISES.

1.*—**Tumbler Bracket.** Draw two end elevations, a side elevation, a plan and the development (not showing the wheels). *Scale, ¾ full size.*

2.*—**Tumbler Bracket with Gearing.** Draw the sectional elevation, end elevation and plan, and also the three radial sections in Fig. 3. *Scale, ¾ full size.*

3.*—**Horizontal Feed Shaft.** Draw the given sectional elevation, and add an end elevation of the clutch. *Scale, full size.*

4.*—**Complete Gearing.** Draw the given sectional side elevation and end elevation, and add a plan of the tumbler bracket—without the pinions A, B, C, D—projected from the sectional elevation. *Scale, ¾ full size.*

5.*—**Complete Feed Gear Box.** Draw a sectional side elevation, a front elevation with covers on, a plan projected from the sectional elevation, and a front elevation—with covers removed—to the right of the plan. *Scale, ⅜ full size.*

CALCULATION OF FEED MOTIONS.—*Continued.*

Cross feed of tool bar per revolution of table = revolutions of $FS_2 \times \frac{5}{40} \times \frac{1}{4} \times \frac{F_7}{G_7}\left[\text{or } \frac{F_6}{G_6} \text{ or } \frac{F_5}{G_5}\right]$

∴ for the maximum speed of FS_2, the cross feeds are	·7877, ·42, ·0944 ins		
„ 1st intermediate speed „ „	·5450, ·2907, ·0653 ins		for one revolution of table.
„ 2nd „ „ „ „	·3326, ·1774, ·0399 ins		
„ minimum „ „ „	·2301, ·1227, ·0276 ins.		

For the down feed of the tool bar the motion of the feed shaft is transmitted through the worm **B** and wheel W_{11} (see Plate XXXVI.) to the rack pinion P_7, which has a pitch circle diameter of 2¼."

For one revolution of P_6 the cross feed is ¼", and the down feed $\frac{1}{28}$th of the circumference of the rack pinion, *i.e.*, $\frac{1}{28} \times 2\frac{1}{4} \times \pi$.

$$\therefore \text{Cross feed : down feed} = 25 : 2527.$$

$$\therefore \text{Down feed} = \frac{\text{Cross feed} \times 2527}{\cdot 25.}$$

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* These Exercises are intended for Advanced Students.

48-INCH BORING AND TURNING MILL.

PLATE XXXIV

TUMBLER BRACKET AND GEARING FOR L.H. FEED GEAR BOX.

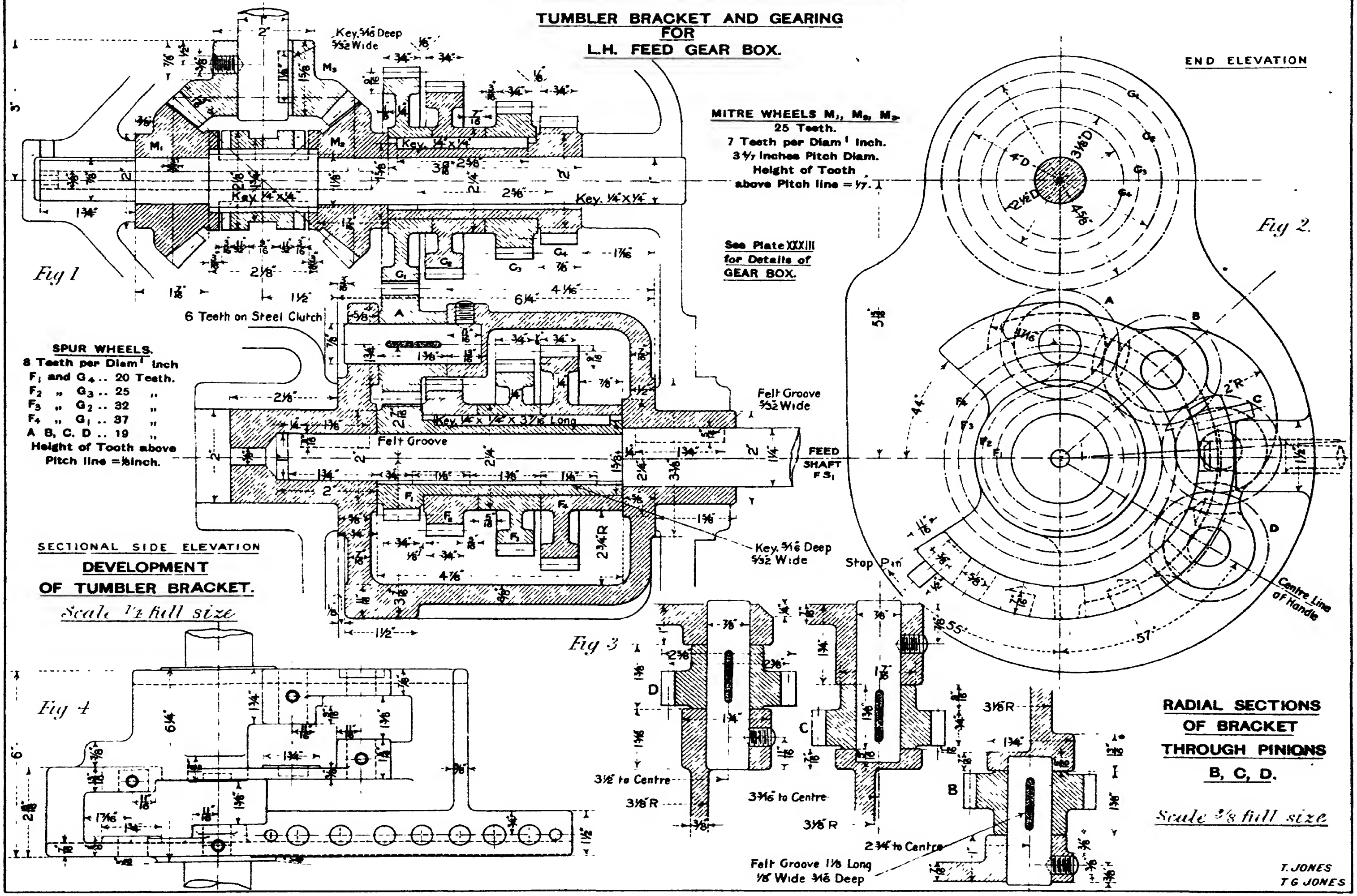


Plate XXXV.—BORING AND TURNING MILL.

RIGHT-HAND SADDLE, SLIDE, AND BORING BAR. — The coloured drawing shows the general arrangement of the several parts which are detailed on Plates XXXVI. and XXXVII. The only point of difference between the L.H. saddle, &c., and the R.H.—other than that due to their being of opposite hands—is the form and position of the nut connecting the saddle with the feed screw. Sufficient detail is shown in the drawing to make clear this difference.

In its cross motion the saddle is guided only by the lower flange of the cross slide, and this ensures not only increased accuracy but greater rigidity to the tool bars. Mounted on the front of the saddle is the swivel slide, which is capable of an angular displacement of 45° on each side of its normal position. The boring bar is guided by two bearings on the swivel slide; and is balanced by means of a patent spring balance arrangement, which is contained in the head of the casting above the swivel slide.

During the boring the bar is moved automatically by the feed shaft of the cross slide; but, by slackening back the four-armed nut in front of the hand wheel, it may be quickly moved by the latter.

Plate XXXVI.

LEFT-HAND SADDLE.—The saddle is held against the vertical face of the cross slide by two plates, which bear against the backs of the top and bottom flanges; but it is guided in its cross motion only by the lower flange, rigid contact with this part being secured by the brass wedge M. At the back are deep facings for the bracket which carries the worm B, and for the feed nut N; and the centre is bossed out backwards and forwards respectively to give support to the hollow pinion shaft, and to provide a centre about which the swivel slide turns. The saddle is clamped to the cross slide by a ¾″ screw and brass pad.

SWIVEL SLIDE.—This slide is required for the purpose of enabling the tool bar to work in an inclined position. It is clamped to the saddle by five ⅞″ bolts, which fit in a circular T groove in the face of the latter, and is guided in its angular motion by the projecting centre of the saddle and its annular facing. On the curved edge is a segmental rack, gearing with the worm C, which is rotated by hand when it is necessary to adjust the angular position of the bar. The upper and lower supports for the bar have caps which half surround the bar, and the lower one can be tightened up against the bar by turning the handle H.

When the boring bar is not working at an angle the bolt K is passed through the lower cap and screwed into the saddle, and thus there is no possibility of the normal position of the bar being accidentally altered.

It is clear from Fig. 3 and the detailed drawings of Figs. 4 and 5 how the motion of the feed shaft is transmitted to the rack on the boring bar through the worm B, the wheel W_{11} and the pinion P_7. The worm wheel is not connected directly with the pinion shaft, but can turn on the end of the spindle which runs through it; and when it is required to give an automatic down feed the wheel is pulled up against the conical end of the pinion shaft by the steel nut L, and then the shaft is driven by the frictional resistance between the conical surfaces in contact.

(For the calculation of feeds see the notes to Plates XXXIII. and XXXIV.)

EXERCISES.

Plate XXXV.

1*.—**Complete Saddle, Swivel Slide, &c. (R.H. or L.H.).** Draw two elevations, referring to Plates XXXVI and XXXVII. for dimensioned details. *Scale, 3 ins. = 1 foot.*

Plate XXXVI.

2.—**Saddle.** Draw two elevations and a plan, omitting worms, wheels and bracket, but showing the wedge and the section of the cross slide. *Scale, 4 ins. = 1 foot.*

3.—**Swivel Slide.** Draw two elevations, a sectional side elevation—through the centre of the bar bearings—to the left of the front elevation, and a plan. Show the hand wheel bracket. *Scale, 4 ins = 1 foot.*

4*.—**Saddle and Swivel Slide.** Draw the three views of the R.H. saddle and swivel slide corresponding with those given in Figs. 1, 2, and 3, and in the plan show the worm wheel in section. *Scale, 4 ins. = 1 foot.*

* These Exercises are intended for Advanced Students.

48-INCH BORING AND TURNING MILL.

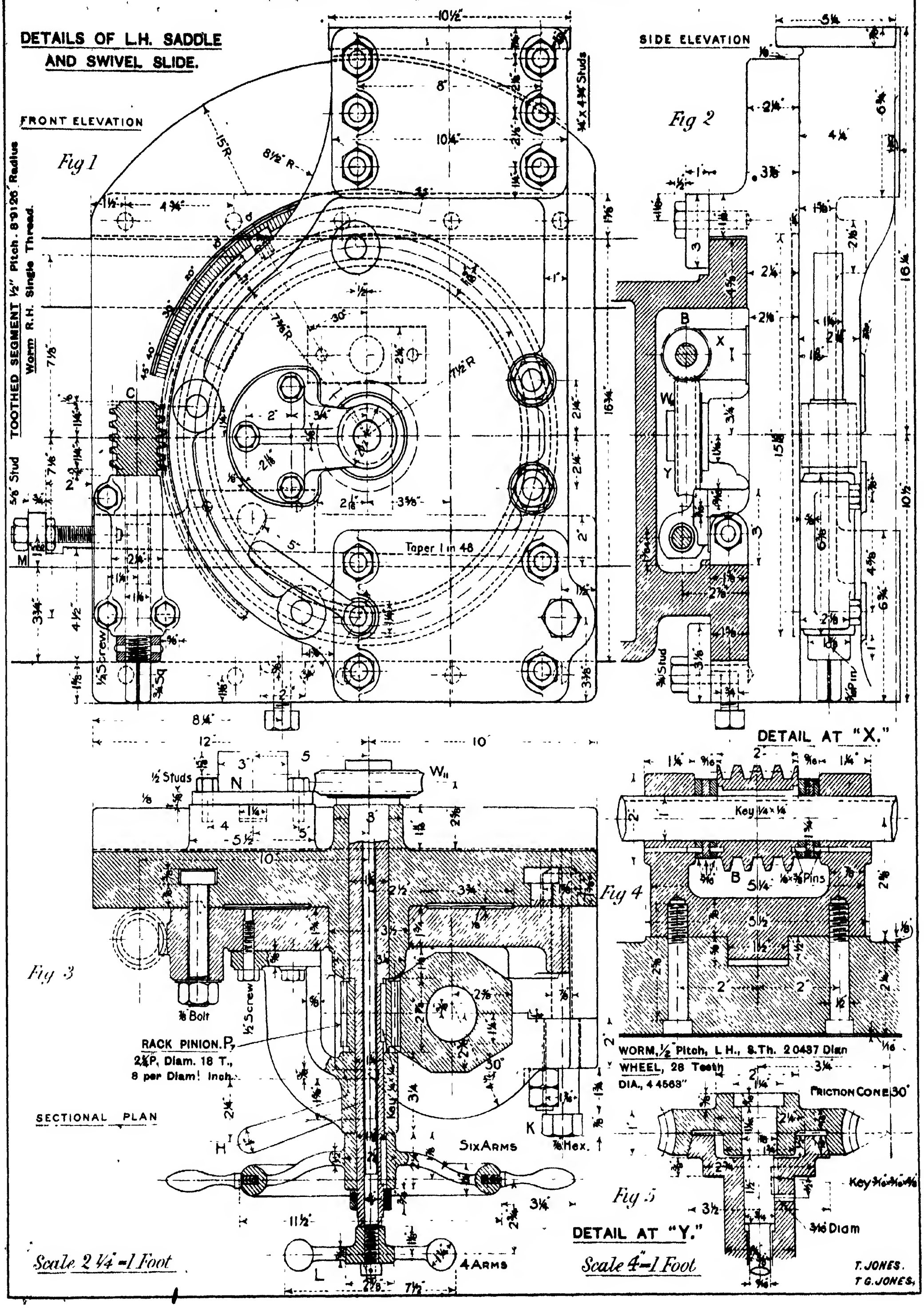


Plate XXXVII.—BORING AND TURNING MILL.

BALANCING ARRANGEMENT FOR TOOL BAR.—These drawings represent in detail the tool bar, and the patent balancing arrangement by means of which the bar may be easily raised or lowered without the use of chains and weights.

The bar is a hollow casting of iron, with the front and back faces bevelled off at an angle of 30°. Its lower end is bored to receive the conical end of the tool holder. The method of fixing and removing the holder by means of cotters is clearly indicated in Fig. 3.

A pin passes through the bar near the top, and to it is attached the end of a small steel cable which is wound round the fusee F contained in the head of the column U. To the fusee shaft is attached one end of a coiled spring, while its other end is fixed to the inside of the worm wheel R. By rotating the wheel R with the worm Q the spring can be made to exert on the fusee shaft sufficient torsion to counteract the weight of the tool bar. The worm also serves to lock the wheel when the spring is adjusted.

EXERCISES.

1.—**Tool Bar and Holder.** Draw the front elevation, the sectional side elevation and the plan. *Scale, ½ full size.*

2.—**Fusee.** Draw the two given views. *Scale, full size.*

3.—**Column U.** Draw the front and side elevations and plan, showing the cover. *Scale, ⅜ full size.*

4.*—**Complete Balancing Arrangement and Tool Bar.** Draw the front elevation, sectional side elevation and plan, showing all the parts fitted together. *Scale, 4 ins. = 1 foot.*

* This Exercise is intended for Advanced Students.

48-INCH BORING AND TURNING MILL.

BALANCING ARRANGEMENT FOR TOOL BAR (L.H.).

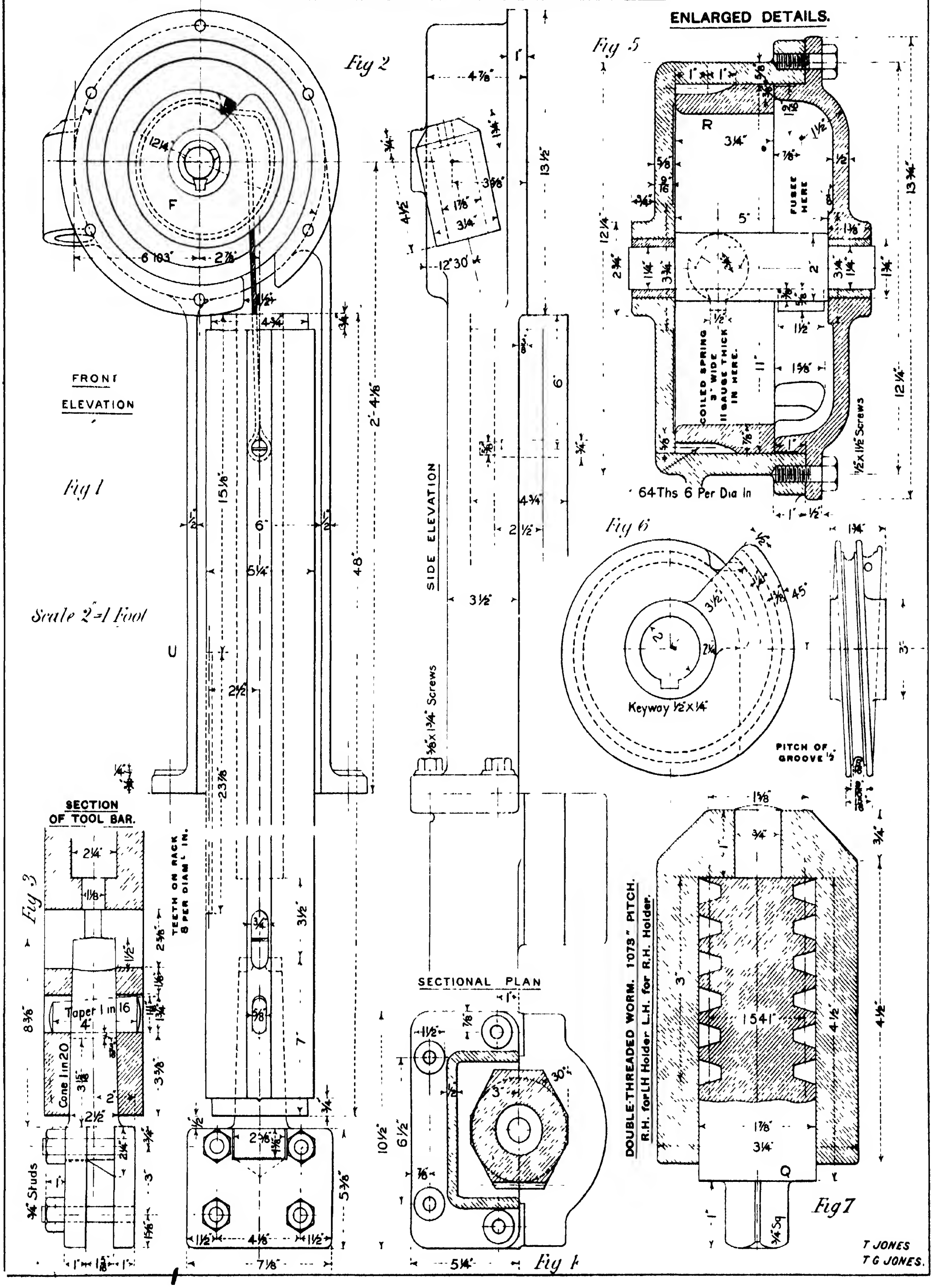


Plate XXXVIII.—BORING AND TURNING MILL.

FEED GEARING FOR CROSS SLIDE.—As previously explained, the number of feeds derivable from the feed gear box—detailed on Plates XXXIII. and XXXIV.—is four, and the change gearing attached to each end of the cross slide increases the number to twelve.

All the necessary shafts and wheels are carried by a small bracket, which is fixed to the back of the cross slide—by four $\frac{3}{8}''$ screws—with its outer end flush with the end of the slide.

To the inner end of the bracket is fixed a case, and through it passes the vertical feed shaft FS_2. As shown in Fig. 4 the five-threaded worm A derives its motion from this shaft, and through the worm wheel W_{10}, transmits it to the shaft S_1. The three wheels F_5, F_6, F_7 are fixed together, and are movable along the shaft S_1 over a long feather key. The parallel shaft S_2 has keyed to it the three wheels G_5, G_6, G_7, and they are so disposed, that by moving the three wheels F sideways, one or other of them may be put into gear with the corresponding wheel on S_2, or all the wheels may be put out of gear.

For the position of the sliding wheels shown in the drawings F_7 is driving G_7, and the increase of speed is a maximum; and when they are moved to the right by $1\frac{7}{8}''$ F_5 gears with G_5, and the reduction of speed is a maximum. By moving the wheels $\frac{15}{16}''$ to either side of the given position all the wheels are out of gear, and the feed motion is not transmitted to the shaft S_2.

In order that the sliding wheels may be moved from one position to another with precision and certainty, a small fork fits slightly over the rim of the largest wheel F_7, and is pinned to a sliding rod S. This rod has on its under surface a groove $\frac{1}{4}'' \times \frac{1}{8}''$ deep, and in the groove are five shallow conical recesses as shown in Fig. 1. It is held endways, sufficiently firmly, by the conical end of a small spring loaded plunger—detailed in Fig. 5—but it is possible by a little force to move the rod, and so alter the positions of the sliding wheels relative to the others. The small pointer, fixed to S and moving over the graduated pin V, enables the operator to see at a glance the rate of feed given to the tool.

As explained in the notes to Plate XXXII., the pinion P_4 is in gear with the wheel P_5, and the pinions P_6 on the ends of the feed shaft and screw respectively derive their motion from the latter wheel.

EXERCISES.

1.—**Bracket.** Draw two elevations and a plan, showing the shafts but not the wheels. *Scale, ½ full size.*

2.—**Worm and Wheel Case.** Draw two elevations and a plan, showing the worm. *Scale, ¾ full size.*

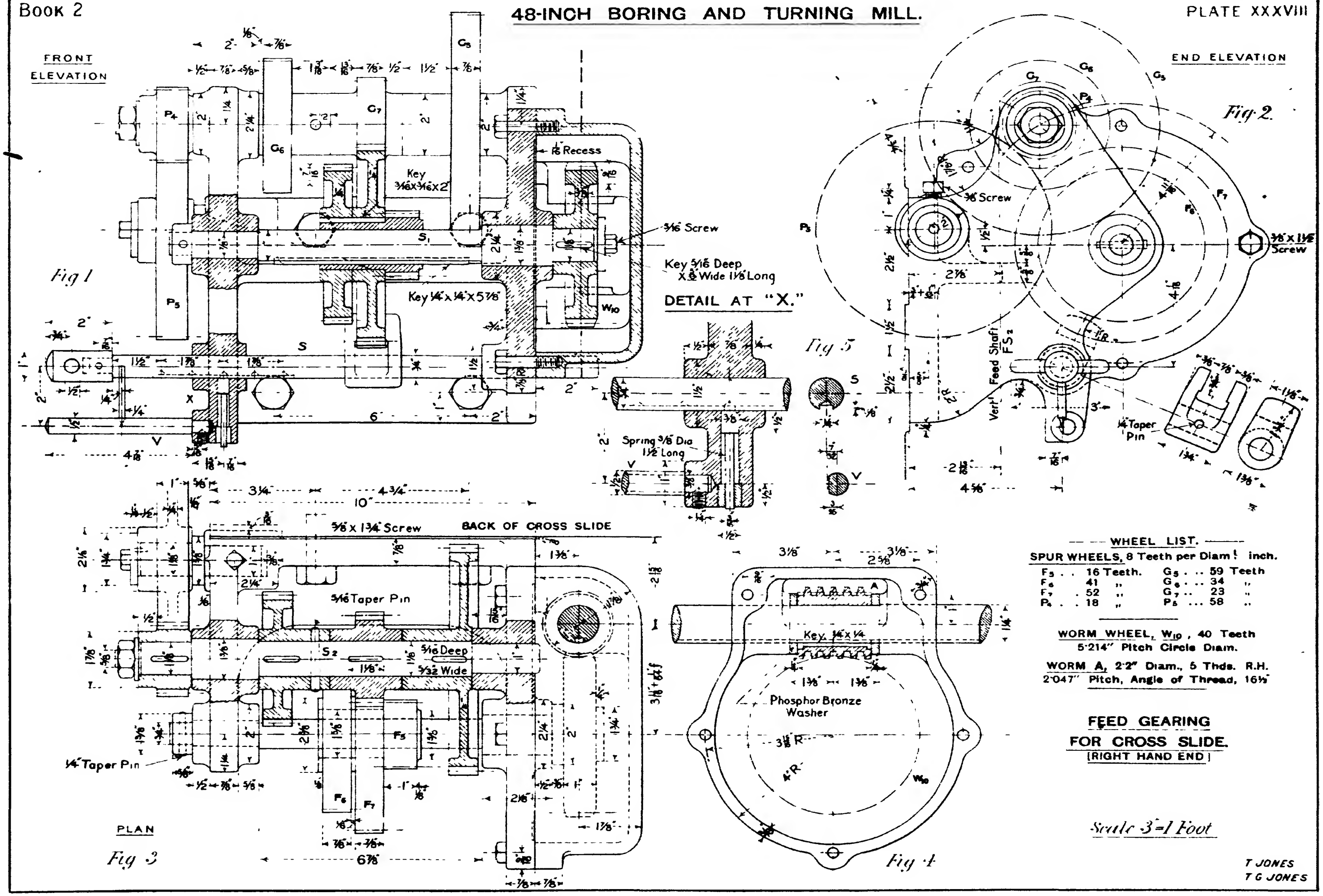
3.*—**Complete Feed Gearing.** Draw the four given views. *Scale, ½ full size.*

* This Exercise is intended for Advanced Students.

Book 2

48-INCH BORING AND TURNING MILL.

PLATE XXXVIII



WHEEL LIST.

SPUR WHEELS, 8 Teeth per Diam! inch.

F_5	16 Teeth.	G_5	59 Teeth
F_6	41 "	G_6	34 "
F_7	52 "	G_7	23 "
P_4	18 "	P_5	58 "

WORM WHEEL, W_{10}, 40 Teeth
5·214" Pitch Circle Diam.

WORM A, 2·2" Diam., 5 Thds. R.H.
2·047" Pitch, Angle of Thread, 16½°

FEED GEARING FOR CROSS SLIDE.
(RIGHT HAND END)

Scale 3"=1 Foot

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Plate XXXIX—HORIZONTAL MILLING MACHINE.

GENERAL DESCRIPTION.—This machine, of which details are given on the five following plates, is made by Messrs. Webster and Bennett, Coventry, and is very suitable for repetition work of moderate size—being compact, rigid and simple in construction. The automatic travel of the table is 18 inches; the cross adjustment is six inches, and the greatest distance between the table and the spindle, 13 inches; hence the three dimensions given with the title of the machine.

The machine body B is a single casting with a base of substantial area, and the inside is arranged as a tool cupboard. The counter-shaft carries a cone pulley, the same size as that on the driving shaft, and runs at 160 revolutions per minute. The spindle, which is hardened and ground, runs in adjustable conical bearings, and its front end is bored taper for the reception of the cutter mandrel CM. The outer end of the mandrel is supported by the adjustable overhanging arm OA.

With single gear the three possible speeds of the cutter are 288, 160 and $88\frac{8}{9}$ revolutions per minute; while with the back gearing, which reduces the speed in the ratio of 1 to $\frac{5}{29}$, the speeds are 49·6, 27·6, 15·3 revolutions per minute.

The vertical slide VS is held against the vertical planed faces of the machine body, and moved up and down by a screw S_2 and a hand wheel HW. The cross slide, carried on the vertical slide, is movable by hand by means of a screw, and on the top of it is the table T to which the work to be milled is bolted. The table is fed and tripped automatically or by hand in the direction of its length.

The feed is effected by means of belt and pulley gearing from the driving pulley through the pulley P_3. Cone pulleys admit of variation of the feed; and in order that the feed belt may be sufficiently tight for all vertical positions of the table it passes round adjustable tightening rollers J. One end of the feed shaft FS is carried by a swivel bearing on the end of the bracket R; and when the feed is to be stopped, automatically or by hand, the other end is lowered sufficiently to throw the worm L out of gear with the worm wheel W_5. The table screw is double-threaded for the quick return of the table by hand.

When the driving pulley P_0 is locked to the wheel W_4, and the back shaft out of gear, *i.e.*, *Single gear*, the four rates of feed are approximately ·025″, ·0122″, ·0065″, ·0032″ per revolution of the cutter. When using the *back gearing*, the feeds are ·145″, ·071″, ·0375″, ·0185″ per revolution of the cutter.

The approximate weight of the complete machine is $13\frac{1}{2}$ cwts.

EXERCISE.*

Complete Machine. Draw the two given views. *Scale, 2 ins. = 1 foot.*

If the drawing be made on paper of imperial size, *Scale, 3 ins. = 1 foot.*

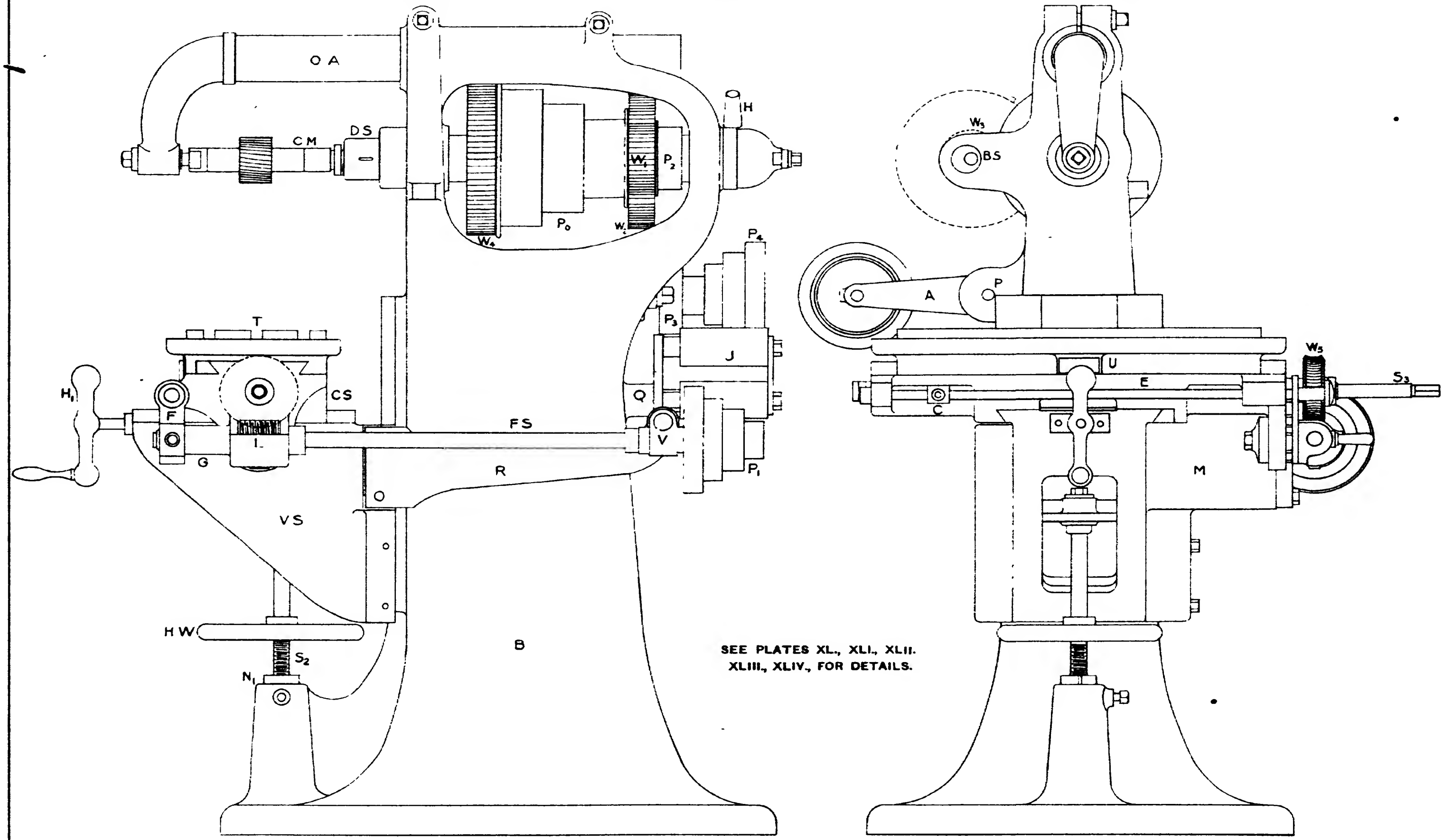
* This Exercise is intended for Advanced Students.

18" × 6" × 13" HORIZONTAL MILLING MACHINE.

SIDE ELEVATION

Scale 1½" = 1 Foot

FRONT ELEVATION



SEE PLATES XL., XLI., XLII. XLIII., XLIV., FOR DETAILS.

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Plate XL.—HORIZONTAL MILLING MACHINE.

MACHINE BODY.—The body is of a neat and simple design, and by reference to the general drawing it will be seen for what purposes the several parts are required. The thickness of metal for the main portion is $\frac{9}{16}''$; and the base, which is flanged out to give stability to the machine, is bolted down by four $\frac{3}{4}''$ bolts. At the front is formed a long vertical boss to carry the nut N_1 through which passes the elevating screw S_2 for the vertical slide. The vertical face is 10″ wide by 1′ – 9″ long, and is made up of two planed strips $2\frac{3}{4}''$ wide with the outer edges bevelled to an angle of 55°.

On the left-hand side of the frame is a rectangular hole, 7″ × 15″, which is closed by the door D, detailed in Fig. 4, and on the two pairs of ledges inside may be placed shelves so that the inside may serve as a tool cupboard.

The two upright portions for the support of the driving shaft are bored out to receive the cast-iron bushes—shown on Plate XLI.—and the top bar, stretching between the two supports for the overhanging arm is of ∩ section (Fig. 3) and split on the top for a short distance from each tightening screw.

On the side of the body, level with the pulley shaft, are two arms for the support of the back shaft; and 9″ below them is a shorter arm P to which is fixed the arm A (Fig. 2, Plate XLIV.). To the boss Q is screwed the pin for one of the tightening rollers J.

EXERCISES.

1.—**Door of Tool Cupboard**. Draw three elevations and a sectional plan. *Scale, 6 ins. = 1 foot.*

2.*—**Machine Body.** Draw the two given elevations and add the plan. *Scale, 2 ins. = 1 foot.*

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* This Exercise is intended for Advanced Students.

18" × 6" × 13" HORIZONTAL MILLING MACHINE.

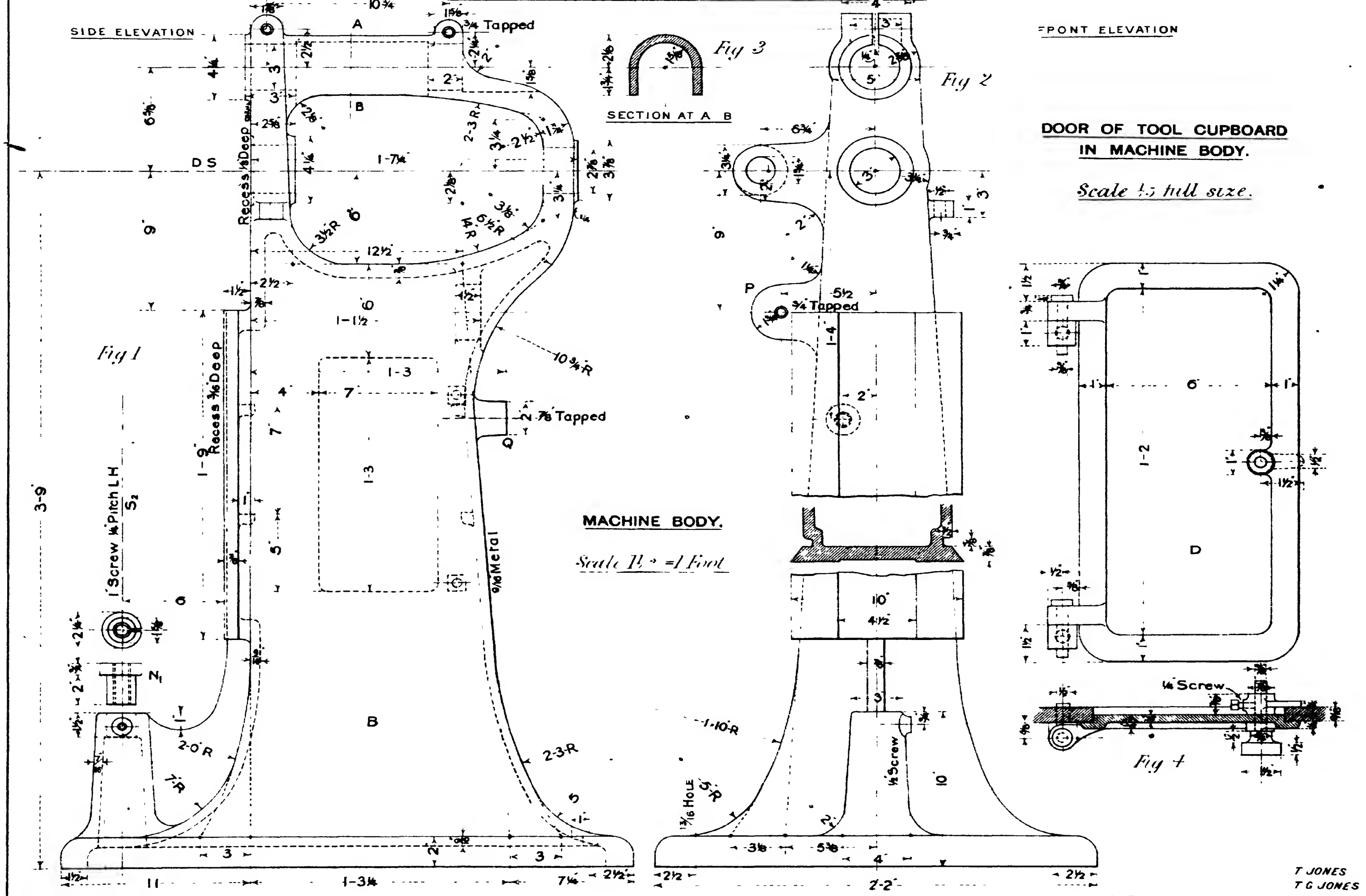

Plate XLI.—HORIZONTAL MILLING MACHINE.

DRIVING GEAR.—The driving shaft is supported at its two conical ends in cast-iron bushes, driven into the front and back uprights of the frame. The larger end of the shaft, which is bored out to receive the cutter mandrel, is turned to a taper of 1 in 6; and at the other end is a loose conical bush fitting over a feather key in the shaft. The back end of the shaft is screwed with a fine thread to receive the two circular lock nuts which bear on the conical bush; and the end thrust is taken by a steel screw supported in a hemispherical cup containing oil, which is itself screwed to the outer end of the bearing bush.

The arrangement of the driving pulley and back gearing is the usual one; the pulley P_0 runs loose on the shaft, and may be locked to the wheel W_4 by a sliding bolt when the machine is running single gear. The pinion W_1 and the feed pulley P_2 fit on the extended end of the main pulley, and are keyed to it by a long pin $\frac{3}{8}''$ diameter.

The hollow cast-iron back shaft BS has cast with it the pinion W_3, and keyed to it is the wheel W_2. The spindle on which this shaft runs is keyed at its ends to cast-iron bushes bored eccentrically; and by turning it through 180° by means of the handle H, the wheels are put in or out of gear with those on the driving shaft. The two segmental stops, Fig. 5, limit the motion of the handle to the required amount. The overhanging arm OA is held firmly in the two split supports by clamping screws. The outer end of the mandrel turns in a conical split brass bush, carried by the end of the arm; and, by being pulled into the slightly less tapered hole by a screw, admits of a little adjustment in internal diameter to take up the wear.

The mandrel CM is driven from the driving shaft through a small cotter; and for its removal the arm OA is pulled out a little and turned, and then the circular nut J is screwed back to press on the end of the driving shaft. The $8\frac{1}{2}''$ length of the mandrel, other than that portion occupied by the cutter, is filled up by bushes (lengths 1″ and 2″), and the last one fits on the screwed end. For heavy cutting the arm may be stiffened by means of removable braces (not shown in the drawings).

SPEEDS OF MANDREL.

The counter-shaft makes 160 revolutions per minute, and carries a cone pulley, the same size as that on the machine.

(*a*) **Single Gear.**—(Neglecting the slip of the belt.)

$$\frac{160 \times 9}{5} = 288, \qquad \frac{160 \times 7}{7} = 160, \qquad \frac{160 \times 5}{9} = 88\tfrac{8}{9} \text{ revolutions per minute.}$$

(*b*) **Back Gear.**—The speed of the pulley is reduced by the back gearing in the ratio of $1 : \dfrac{26 \times 20}{52 \times 58}$ or $1 : \dfrac{5}{29}$.

∴ Speeds of Maudrel are :—

$$\frac{288 \times 5}{29} = 49{\cdot}6. \qquad \frac{160 \times 5}{29} = 27{\cdot}6. \qquad \frac{800 \times 5}{9 \times 29} = 15{\cdot}3.$$

EXERCISES.

1.—**Overhanging Arm.** Draw two elevations and a plan. *Scale, ½ full size.*

2.*—**Driving Gear.** Draw the given elevation, and add a complete plan, showing the upper part of the machine body, and the back shaft and supports in section as in Fig. 4. Also add an end elevation to the left of the side elevation. *Scale, ⅜ full size.*

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* This Exercise is intended for Advanced Students.

18" × 6" × 13" HORIZONTAL MILLING MACHINE.

DETAILS OF DRIVING GEAR, CUTTER MANDREL AND ARM.

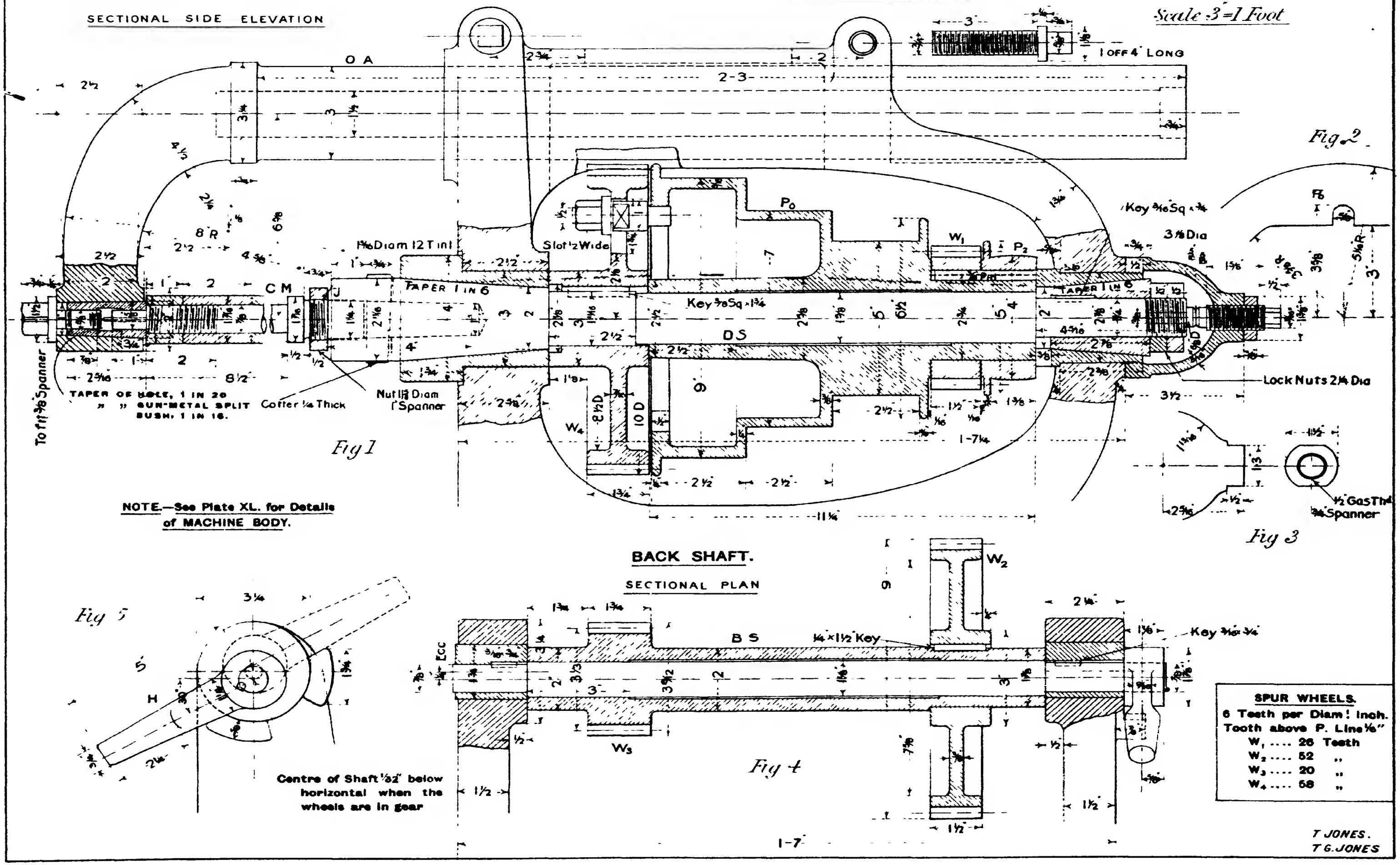


Plate XLII.—HORIZONTAL MILLING MACHINE.

VERTICAL SLIDE.—This slide carries the cross slide and the table, and so for the vertical adjustment of the latter it is made to slide over the vertical face of the machine body by the vertical screw S_2 and the hand-wheel HW. Only the portion of S_2 below the wheel is screwed, and this works in the nut N_1 carried by the vertical projection of the body. The upper part is attached to the cross bar of the slide so that it may rotate, and transmit to the slide only its vertical motion of ¼" for each revolution of the wheel. The slide is held against the face of the machine as shown in Fig. 3. The cross slide—detailed on Plate XLIII.—is movable over the horizontal face by the screw S_1 and the balance handle H_1.

At the right-hand side of the slide is an arm M to which is fixed the bracket R for the support of the feed shaft FS at the pulley end. To stop the feed of the table, either automatically or by hand, it is necessary to disconnect the feed worm L from the wheel by lowering the front end of the shaft—hence the necessity for the swivel bearing V.

The feed shaft and pulley P_1 move up and down with the slide so that it is necessary, for a considerable movement, to re-adjust the tightening rollers for the feed belt before starting the feed. However, for repetition work, or for the milling of pieces varying in thickness by only a few inches, the feed belt would be sufficiently tight for all positions of the table, and there would consequently be no necessity for the adjustment as mentioned above.

As the machine is a horizontal milling machine, the only motion of the table required to be automatic is the horizontal motion at right angles to the cutter mandrel. The cross and vertical adjustments are made by hand before starting the machine.

EXERCISES.

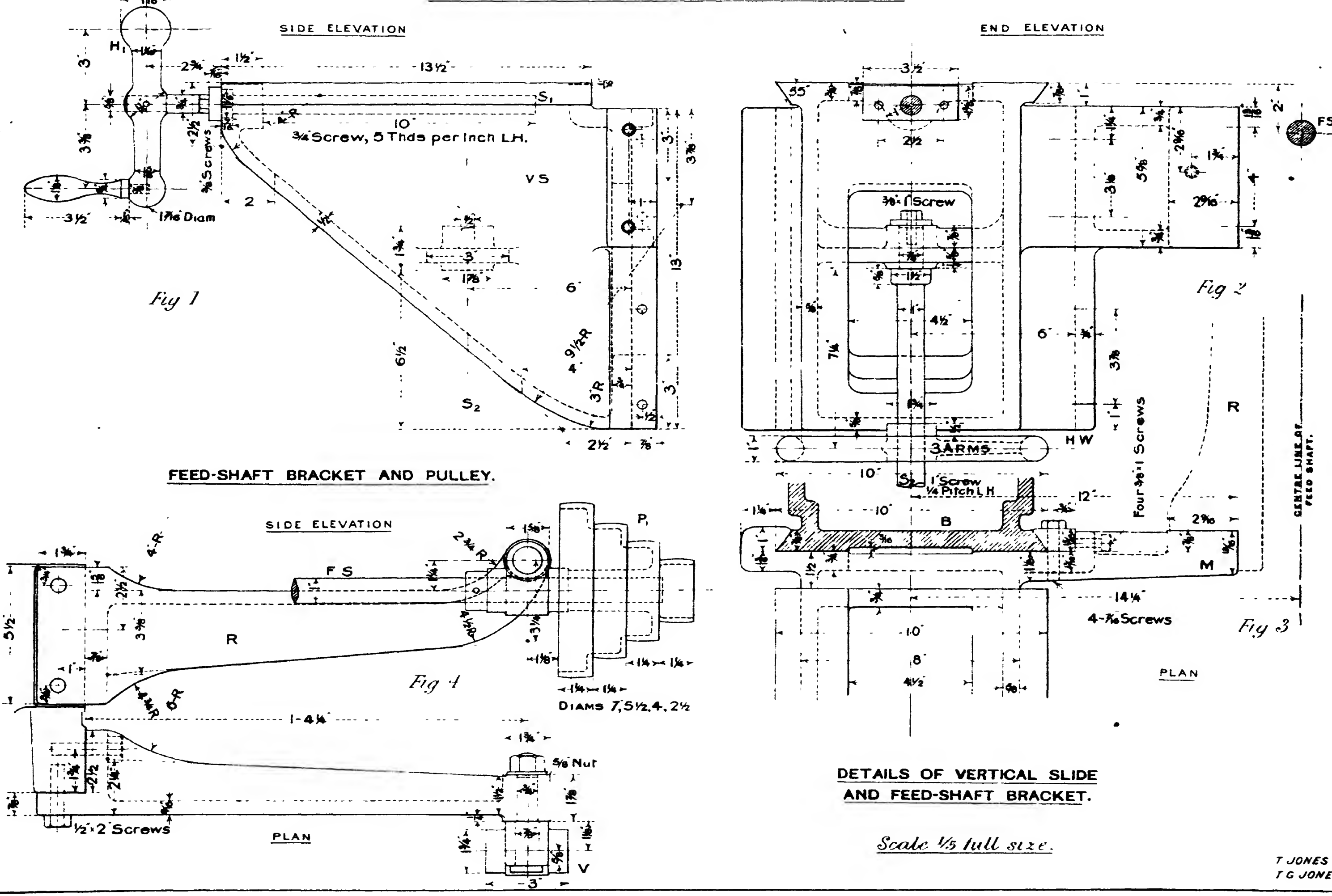
1.—**Feed Shaft Bracket and Pulley.** Draw and complete the two given views (Fig. 4), and add an end elevation to the right of the side elevation. *Scale, ⅜ full size.*

2.*—**Vertical Slide.** Draw two elevations and a complete plan. *Scale, ⅜ full size.*

3.*—**Slide with Feed Bracket, &c.** Draw two elevations and a plan, showing the bracket, &c., in position on the slide. *Scale, ¼ full size.*

* These Exercises are intended for Advanced Students.

18″ × 6″ × 13″ HORIZONTAL MILLING MACHINE.



DETAILS OF VERTICAL SLIDE AND FEED-SHAFT BRACKET.

Scale 1/5 full size.

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Plate XLIII.—HORIZONTAL MILLING MACHINE.

TABLE AND CROSS SLIDE.—The cross slide moves over the horizontal face of the vertical slide by means of the nut N_1 and the screw S_{11} and is adjusted to the bevelled edges by the separate strip as shown in Fig. 1. The nut is only held in position by a 1″ peg fitted into the base of the slide.

In order to provide a substantial sliding surface for the long table T, the slide is extended on both sides of the portion fitting on the vertical slide. At the right-hand end projects the table screw S_3 which carries the worm wheel W_5, and immediately below is a bracket to support the bearing G of the feed shaft. The worm L, fitted with a key $\frac{1}{4}$″ square, is driven by the feed shaft along which it can slide during any cross motion of the table, and rotates in the semi-circular recess of the support G. Attached at the front end of G is a plate F containing a hole $1\frac{5}{8}$″ diameter so that it may fit over the collar on the spindle E, which runs the whole length of the slide and carries an adjustable piece C.

When the parts connected with the worm are in the given positions, the rotation of the feed shaft is transmitted to the table screw S_3, and the table moves to the left. When the plate U on the table reaches the stop C, it is moved to the left until the collar on the spindle E is drawn out of the plate F, and then F drops on to the $\frac{3}{4}$″ diameter end of the spindle. To put the worm and wheel in gear again the small handle on the support G is lifted, and the spindle E is forced back into position by the coiled spring which bears on the collar. The stop C is fixed in any position by pressing the small key in it against the flat on the spindle by the $\frac{5}{16}$″ screw.

The table, exclusive of dishes, is 22″ × $8\frac{1}{2}$″, and has three planed T slots. The nut N_3 is fixed on the underside of the table by two $\frac{3}{8}$″ screws, and moves along the semi-circular channel in the cross slide. For the rapid return of the table by hand the screw has a comparatively large pitch, and so is made double-threaded.

The rates of feed per revolution of the cutter are :—

·025, ·0122, ·0065, ·0032 ins. for single gear,
and ·145, ·071, ·0375, ·0185 ins. for double gear.

(*See the notes to Plate XLIV. for calculation of feed.*)

EXERCISES.

1.—**Bearing** G. Draw two elevations and a plan, showing the plate F attached. *Scale, full size.*

2.—**Table**. Draw two elevations and a plan. *Scale, 6 ins. = 1 foot.*

3*.—**Cross Slide.** Draw two elevations and a plan, omitting the nuts, screw S_3, and the spindle E. *Scale, 6 ins. = 1 foot.*

4.*—**Cross Slide and Table.** Draw the given front elevation, complete the plan, and add an end elevation to the left of the front elevation. *Scale, $\frac{3}{8}$ full size.*

* These Exercises are intended for Advanced Students.

18" × 6" × 13" HORIZONTAL MILLING MACHINE.

DETAILS OF TABLE AND CROSS SLIDE.

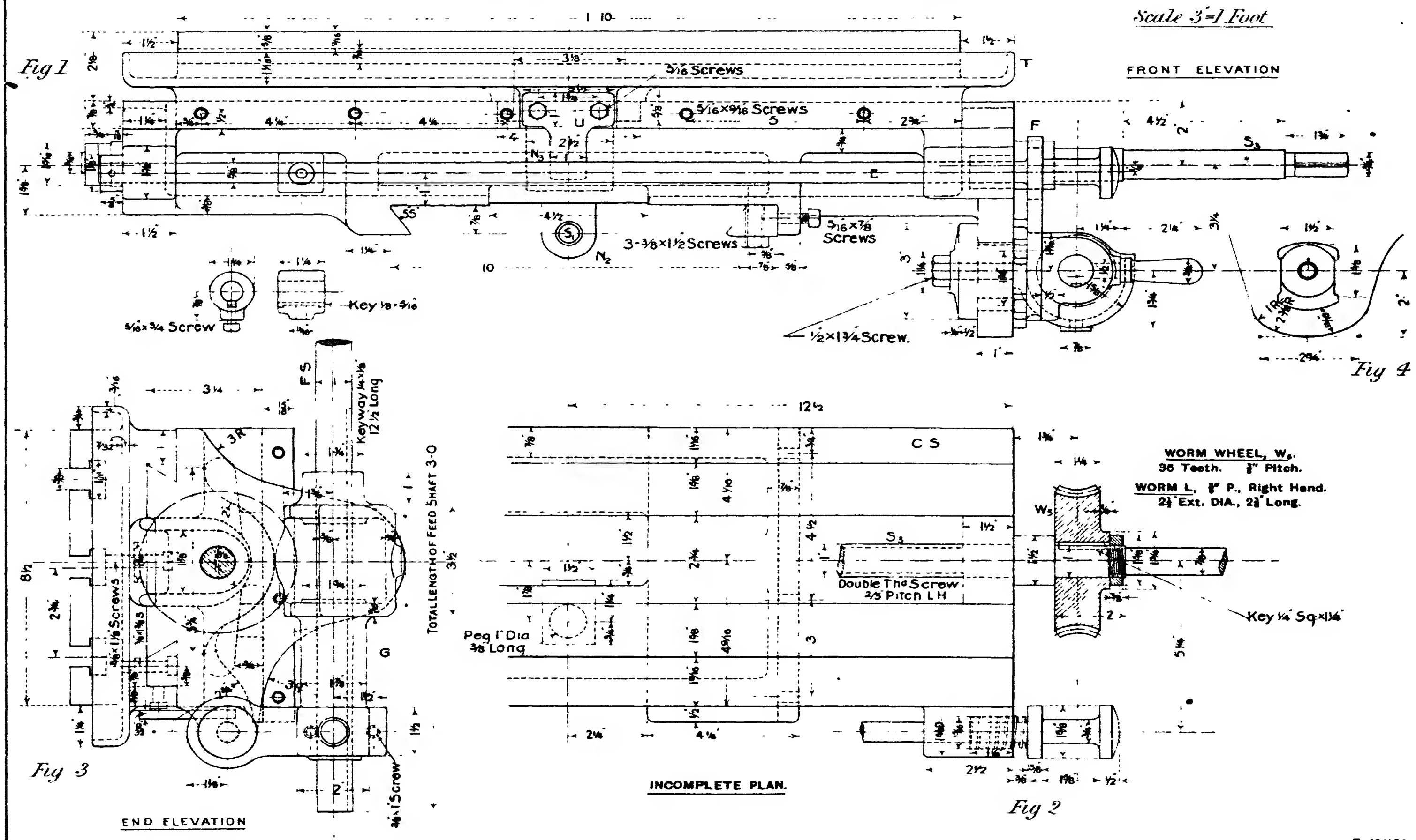

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Plate XLIV.—HORIZONTAL MILLING MACHINE.

ARRANGEMENT OF BELT GEARING FOR FEED.—**Fig. 1** shows the back elevation of the machine, with the belts and pulleys used in the automatic feeding of the table from the main driving pulley.

A crossed belt connects the pulley P_2 on the end of the driving pulley P_6 with the pulley P_3, which is cast with the first cone pulley P_4. The second cone pulley P_1 is on the end of the feed shaft, carried by the vertical slide, and is driven from P_3 by a long belt passing round the tightening rollers J, as shown. If the table, and consequently the pulley P_1, be moved up or down by any considerable amount, it is necessary to move the tightening rollers into some new position, in order that the belt may not be too slack or too tight.

Fig. 2.—The arm is fixed to the projection P on the machine body by the ¾″ screw, and carries the pin on which the pulley rotates.

Fig. 3.—The two tightening rollers have the pins upon which they turn supported by two parallel plates, and one pin is provided with a ⅞″ screw end for attachment to the boss Q on the machine body. The rollers are sufficiently long to receive the belt whatever may be its position on the cone pulleys.

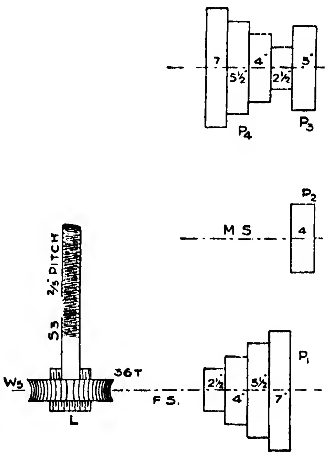
EXERCISES.

1.—**Tightening Rollers.** Draw two elevations and a plan. *Scale, ¾ full size.*

2.—**Feed Cone Pulley and Arm.** Draw the two given views, and add an elevation of the arm and pulley to the right of the given elevation. *Scale, ¾ full size.*

CALCULATION OF FEED FOR TABLE PER REVOLUTION OF THE CUTTER.

The accompanying diagram represents the plan of the belt gearing for the feed of the table. With single gear the cutter rotates at the same speed as the feed pulley P_2



Single Gear:—

$$\left.\begin{array}{ll}\text{Maximum feed.........} & = \frac{4}{5} \times \frac{7}{2\frac{1}{2}} \times \frac{1}{36} \times \frac{2}{5} = \cdot025 \text{ ins.} \\ \text{1st Intermediate feed} & = \frac{4}{5} \times \frac{5\frac{1}{2}}{4} \times \frac{1}{36} \times \frac{2}{5} = \cdot0122 \text{ ins.} \\ \text{2nd Intermediate feed} & = \frac{4}{5} \times \frac{4}{5\frac{1}{2}} \times \frac{1}{36} \times \frac{2}{5} = \cdot0065 \text{ ins.} \\ \text{Minimum feed.........} & = \frac{4}{5} \times \frac{2\frac{1}{2}}{7} \times \frac{1}{36} \times \frac{2}{5} = \cdot0032 \text{ ins.}\end{array}\right\} \text{Per revolution of cutter.}$$

Back Gear.—The feed per revolution of pulley will be as given above, whether the back gearing be used or not; but with the back gearing the cutter rotates slower than the pulley in the ratio $\frac{5}{29} : 1$.

∴ the feed per revolution of cutter with back gearing = feed per revolution of cutter (single gear) × $\frac{29}{5}$.

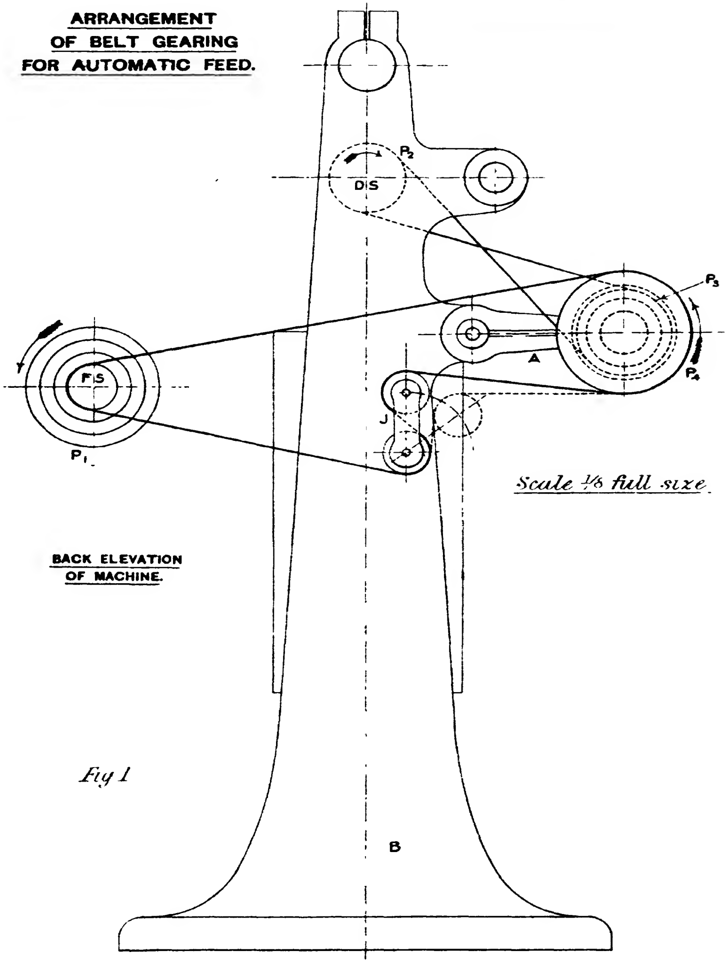
∴ the feeds are:—·145, ·071, ·0375, ·0185 ins.

Book 2.

18" × 6" × 13" HORIZONTAL MILLING MACHINE.

PLATE XLIV.

ARRANGEMENT OF BELT GEARING FOR AUTOMATIC FEED.



BACK ELEVATION OF MACHINE.

Scale 1/8 full size

Fig 1

FEED CONE PULLEY AND ARM.

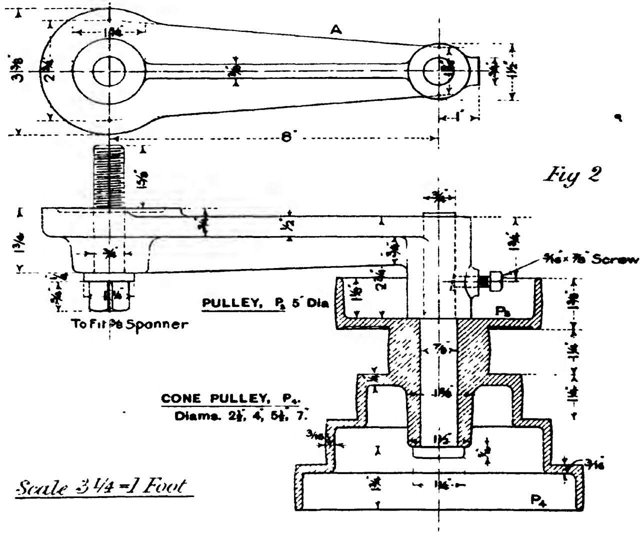


Fig 2

Scale 3 1/4 = 1 Foot

TIGHTENING ROLLERS FOR FEED BELT.

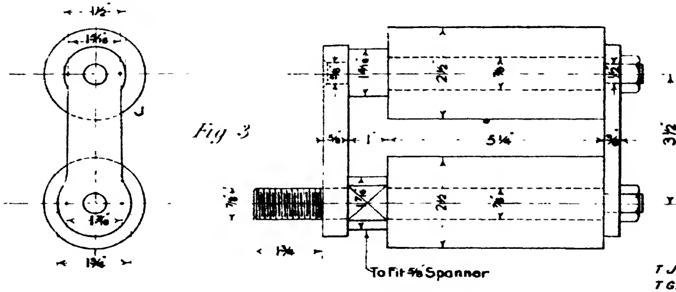


Fig 3

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T. G. JONES

Plate XLV.—PNEUMATIC CHIPPING HAMMER.

THE pneumatic hammer detailed on this plate and also on Plate XLVIII. is made by "The Pneumatic Engineering Appliances Company, Limited," London; and, although only weighing $12\frac{1}{2}$ lbs., is suitable for heavy chipping and caulking when operated with an air pressure of 80 to 100 lbs. per square inch. The piston or plunger is $1\frac{1}{8}''$ diameter with a stroke of $3''$, and is capable of delivering 1,400 blows per minute with a consumption of 20 cubic feet of air.

The hammer consists of the following parts :—The barrel or cylinder **A**, the plunger **B**, the valve-block **C** containing the controlling valves **D**, $\mathbf{D_1}$, the handle **E** in which are placed the throttle valve **F** and the trigger **K** and lever **L** for operating the valve, and the working tool **J**.

The barrel **A** is made of mild steel, and has the large end screwed with a *buttress* thread to receive the handle. It is accurately bored to $1\frac{1}{8}''$ diameter, and in the taper end is forced a hard tool steel nozzle which holds the end of the working tool. Running along the length of the barrel are several small air passages, viz. : **R**, **R**, **P**, **P**, **Q** and **S**, which communicate with the inside of the barrel at definite points as shown in the drawings.

The mild-steel valve-block **C** is placed against the screwed end of the barrel, and is held in position relative to the air passages in the barrel by two $\frac{1}{8}''$ steady pins. The block contains two controlling valves **D**, $\mathbf{D_1}$ of hard tool steel—made hollow for lightness—which control the admission and exhaustion of the air required for the working of the plunger.

The mild-steel handle **E** is screwed tightly on the end of the barrel, and holds firmly the valve-block. The stress on the screwed joint during the working of the hammer acts only in one direction, and hence the screw has a buttress thread. At right angles to the length of the barrel the handle is drilled out to receive the mild-steel bush **H** in which the throttle valve **F** is moved by the trigger **K** and the valve stem lever **L**. The upper end of the valve stem is guided by the case-hardened steel guide **G**, and a coiled spring is placed between **G** and **F** to keep the throttle valve closed except when actuated by the trigger and lever. The screwed end of the air supply pipe is connected with the handle at **Y**.

ACTION OF THE HAMMER.—(*Refer also to the coloured drawing on Plate XLVIII.*) By pressing the trigger **K**, and so actuating the valve stem lever **L**, the throttle valve **F** is raised and the five holes in the liner **H** are partially uncovered. The air under pressure passes into the space **M** in the valve-block, and forces outwards the two valves **D** and $\mathbf{D_1}$ until they are stopped by the caps $\mathbf{C_1}$, $\mathbf{C_1}$, and so the air gains admission to the barrel through the small holes **N**, $\mathbf{N_1}$.

Acting on the back end of the plunger the air pressure forces it outwards until it strikes the tool **J**. During the early portion of the working stroke of the plunger the two pairs of ports p_1, p_2, connected with the passages $\mathbf{P_1}$ **P**, are uncovered and so any air in front of the plunger is discharged along the passages **P**, through the holes p_0 in the valve-block and away through the exhaust holes **V** in the handle. When the ports p_1 are covered by the plunger, the air at atmospheric pressure retained in the barrel is compressed and serves as a slight cushion for the plunger.

When **B** is at the outward end of its stroke—in the position shown on the drawing—the port q is in communication with the annular space round the plunger. Now q is at the end of the passage **Q** in the barrel which is connected with the space to which the holes $\mathbf{N_1}$ lead by the hole $\mathbf{Q_1}$ in the valve-block; and consequently, when the plunger has struck the tool, air under pressure passes by way of q, through the ports r_1, r_1 along the passages **R**, **R** to the outer ends of the controlling valves, and acting on the larger area of the valves forces them inwards. By doing so the air under pressure behind the plunger escapes through the ports **T** in the valve-block, into the space **U**, and through the exhaust holes in the handle to the atmosphere. At the same time *live* air is admitted through the three small holes d in the valve $\mathbf{D_1}$, through the hole $\mathbf{S_1}$, and along the passage **S** into the barrel by the port s—which is at the front of the plunger—and so the plunger is forced back. However, as soon as the ports p_1, p_2 are uncovered, the air pressure at the front of the plunger, as well as the air pressure behind the valves **D**, $\mathbf{D_1}$, escapes through the passages **P** and into the exhaust space in the handle. When this has taken place, the *live* air, which is constant in the space **M**, acts on the valves as described above, and another working stroke commences.

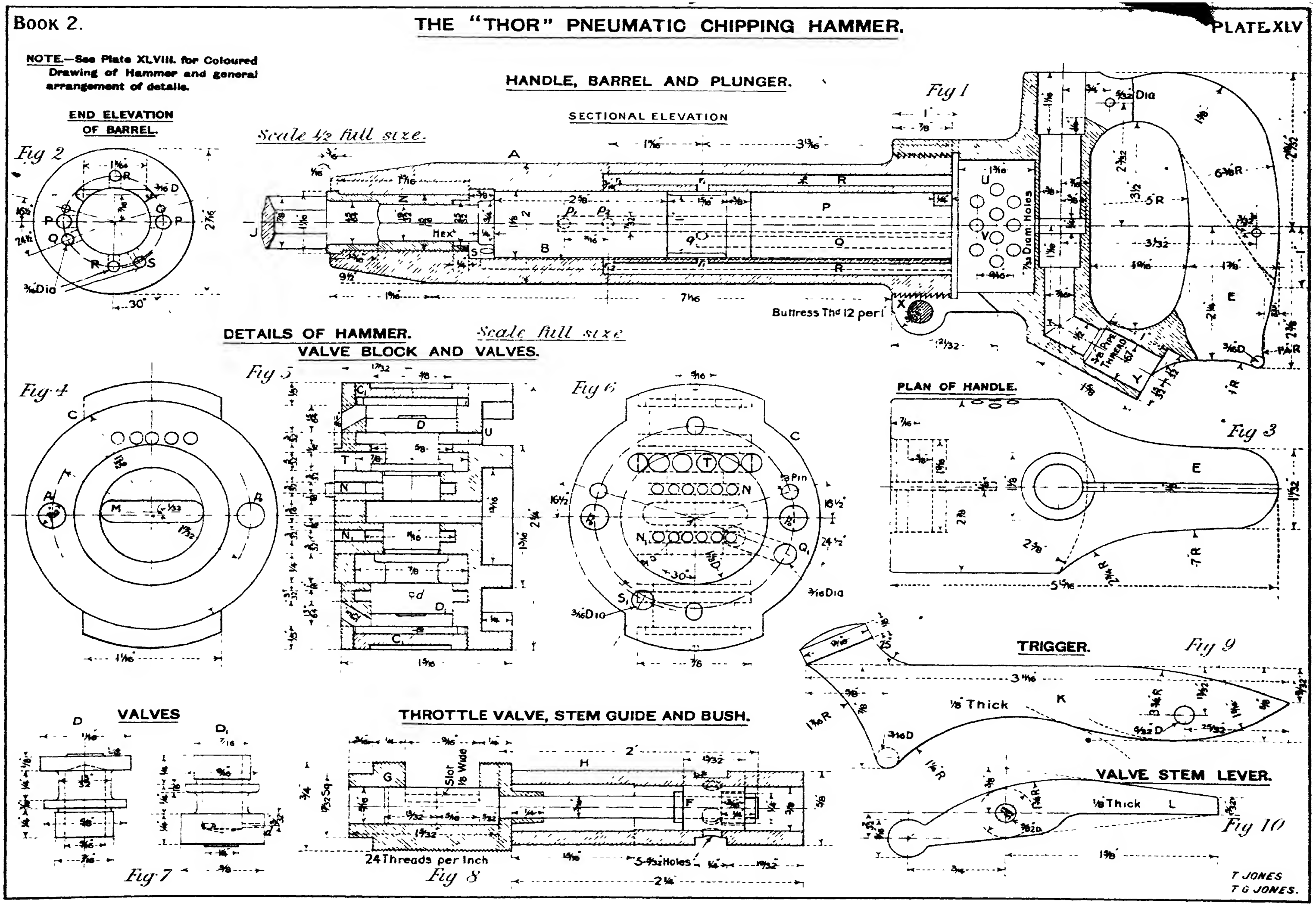
(The passage **Q** is in the front half of the barrel, but for clearness is shown in the section as though it were in the back half.)

Care should be taken to have the air as dry as possible, and free from dust. Before commencing work the hammer should be well oiled through the air inlet. The air carries the oil to the parts which require lubricating; and after using, or before laying the hammer aside, it should be placed in a bath of benzine or coal oil. Before using the tool again, blow out and re-oil.

EXERCISE.

1.*—**Pneumatic Hammer.** Draw the sectional elevation, end elevation, sectional plan and plan. *Scale, full size.*

* This Exercise is intended for Advanced Students.



Book 2.
THE "THOR" PNEUMATIC CHIPPING HAMMER.
PLATE XLV
NOTE.—See Plate XLVIII. for Coloured Drawing of Hammer and general arrangement of details.
END ELEVATION OF BARREL.
Fig 2
HANDLE, BARREL AND PLUNGER.
SECTIONAL ELEVATION
Scale ½ full size.
Fig 1
Buttress Thd 12 per I
Hex
7/32 Diam Holes
3/8 Pipe Thread
DETAILS OF HAMMER.
VALVE BLOCK AND VALVES.
Scale full size
Fig 4
Fig 5
Fig 6
PLAN OF HANDLE.
Fig 3
TRIGGER.
Fig 9
1/8 Thick
VALVES
Fig 7
THROTTLE VALVE, STEM GUIDE AND BUSH.
Slot 1/8 Wide
24 Threads per Inch
5-5/32 Holes
Fig 8
VALVE STEM LEVER.
1/8 Thick
Fig 10
T JONES
T G JONES.

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THE "THOR" PNEUMATIC CHIPPING HAMMER.

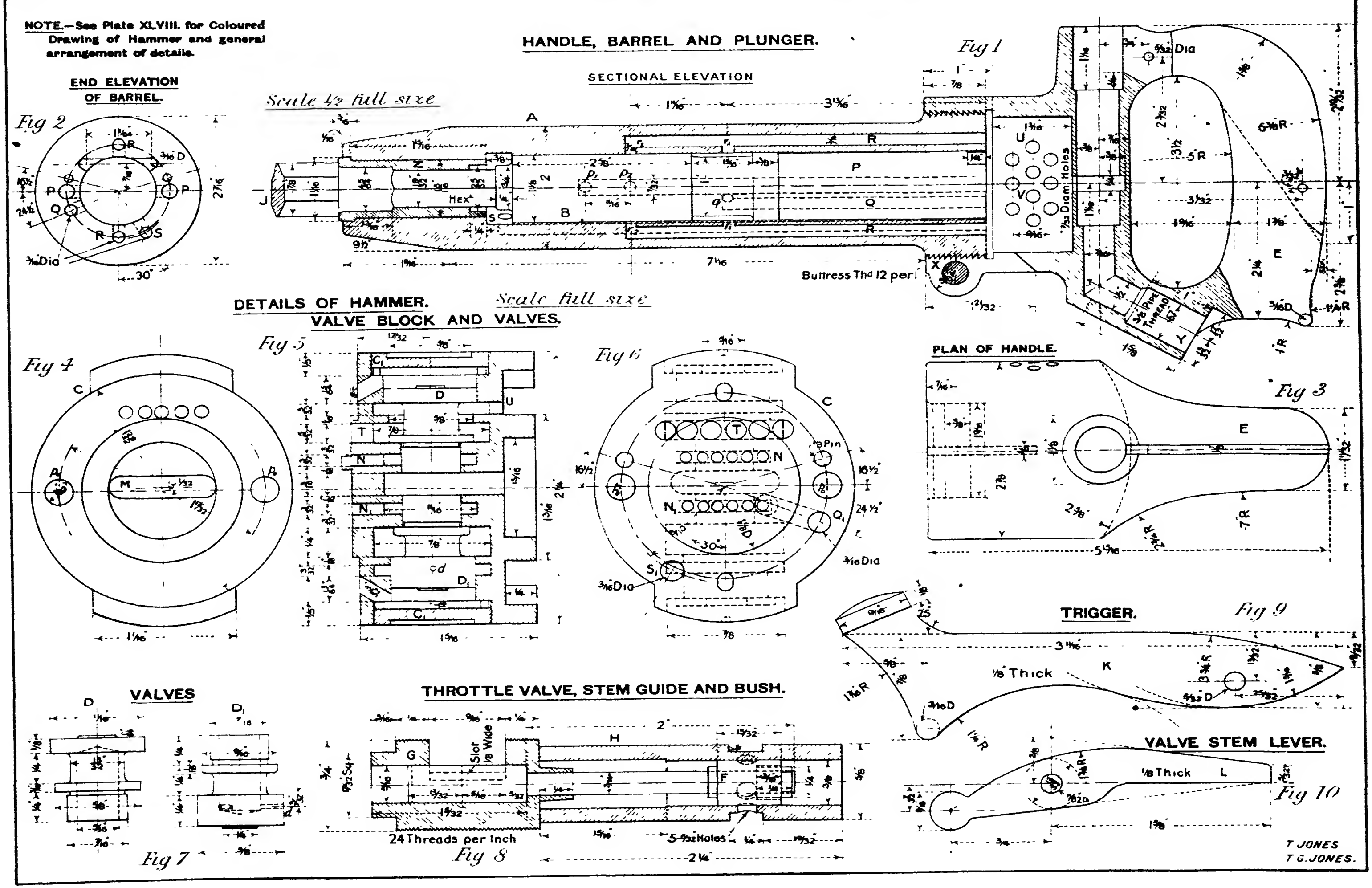
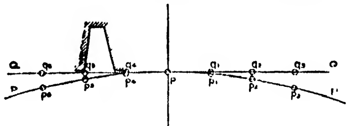


Plate XLVI.—WORM AND WORM WHEEL.

A WORM and a worm wheel are used to connect two non-intersecting shafts at right angles when the angular velocity ratio is large. The worm is simply a short length of screw, with a special form of thread, supported in bearings so that motion parallel to its axis is not possible. The teeth on the worm wheel, if correctly shaped, are such as to have contact with the worm thread along the entire width. Often, however, the teeth are made of uniform section across the rim—being merely twisted spur wheel teeth—and then there is only contact between the thread and a tooth at a point in the central plane. This defect gives rise to excessive friction and wear in the gearing.

The sections of the thread and teeth by the central plane on the worm and wheel respectively are the same as for a rack and wheel, the latter having the same diameter as the worm wheel. For convenience in turning the worm, the involute form of tooth is usually adopted, and then the thread is of triangular section, having an angle of 31°—*i.e.*, double the angle of obliquity, $15\frac{1}{2}$°—at the point. The proportions of a tooth are as follows:—

Thickness of tooth on pitch line, 0·48 pitch. | Height above pitch line, 0·3 pitch. | Depth below pitch line, 0·4 pitch.



When drawing the worm the radial or central section is first obtained, and then helices of 1″ pitch are drawn on the cylindrical surfaces through the four points of the section. (See Plate V Book I., for method of drawing the projection of a screw thread.) The central section of the wheel tooth is formed of involutes of the base circle tangential to the path of contact that makes an angle of $15\frac{1}{2}$° with the pitch line of the worm. To secure line contact between the thread and a tooth, any section of the latter must be the envelope of the corresponding thread section, when the pitch circle of the wheel rolls on the pitch line of the worm In the drawing three sections *bb*, *cc*, *dd*, other than the central one, have been taken to determine the form of a half tooth. Points on the section of the worm thread are obtained by determining the intersections of the helices on the thread with the section plane. Only three helices are shown, viz., those through the point, root and pitch point, but on a larger drawing others may conveniently be introduced. The best method of determining the envelopes of the thread sections is described by Professor Unwin, in his "Elements of Machine Design," and may be given as follows: Draw on a sheet of tracing paper the pitch circle PP of the wheel, showing clearly the centre O and the initial pitch point p. Beginning at p, mark off a number of equal lengths along PP on the tracing and PP on the drawing, and also on OO, the locus of the centre of O, so that when the pitch circle rolls upon the line QQ, the points p_1q_1, p_2q_2..... p_6q_6 will in turn be coincident, whilst the centre O will successively have the positions $o_1, o_2 \ldots\ldots o_6$. Start with the tracing paper in the position shown in Fig 1, and trace out the thread section whose envelope is required. Now move the paper so that the points p_1q_1 are coincident, and the centre is at o_1, and again trace the section. By proceeding so, the several positions of the section, with respect to the pitch circle during the driving of the wheel by the worm, will be obtained. (See Fig. 2.)

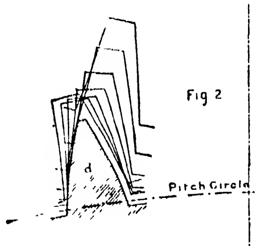
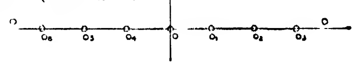


Fig 2

Fig 1.



The tooth section to work with the thread in the plane of section is the envelope of these positions when allowance has been made for a side clearance of [0 52p − 0·48p =]0·04p, and a top clearance as determined from the sectional elevation.

The sections b,c,d, when reversed are the corresponding ones for the other half tooth.

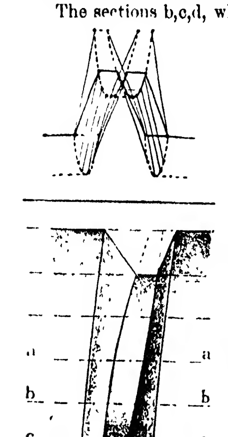


Fig. 3

If the drawing of the worm is large enough to permit making all the sections on the same portion of thread, the tooth sections, when transferred to the drawing paper will be those of a single tooth in their exact relative positions. Whether this plan has been adopted or not, all the tooth sections must now be drawn on tracing paper (see Fig. 3) as sections of one tooth, and placed over the drawing, so that the central section coincides with the same section underneath. Then, projecting from the four points of each section the plans of the lines of a tooth are obtained. It will be seen that the point thickness at the ends is less than in the centre. The section dd is taken to determine the root thickness at the side of the wheel rim, and also the better to obtain the projections of the top edges.

If the worm is single threaded, and the wheel has n teeth, the velocity ratio is $1 : n$ and the theoretical mechanical advantage n. For double and treble threaded worms the velocity ratios are $1 : \frac{n}{2}$ and $1 : \frac{n}{3}$ respectively.

The **efficiency** of worm gearing is greater the less the radius of the worm. It varies from 0·25, for a single threaded worm when its radius is three times the pitch, to 0·66, when the worm has three threads and $r = 1·5$ p. That this form of gearing is not very inefficient when the wheel teeth are correctly cut is evident from the following note taken from "Engineering," of November 19th, 1897.

"Professor Strodola, of Zurich, has obtained an efficiency of 87 per cent, when using worm gearing to transmit 21 H.P., the worm running at 1,500 revolutions per minute. This worm was 3·15in. in diameter, the pitch being 3·2in., and the wheel, which was of gun-metal, had 28 teeth."

A description of a machine for accurately cutting worm-wheel teeth is given by Mr. Gibson in a paper read before the North-East Coast Institution of Engineers and Shipbuilders. This appeared in "Engineering," for April 2nd, 1897.

Book 2 PLATE XLVI.

WORM AND WORM WHEEL.

Scale 1/4 full size

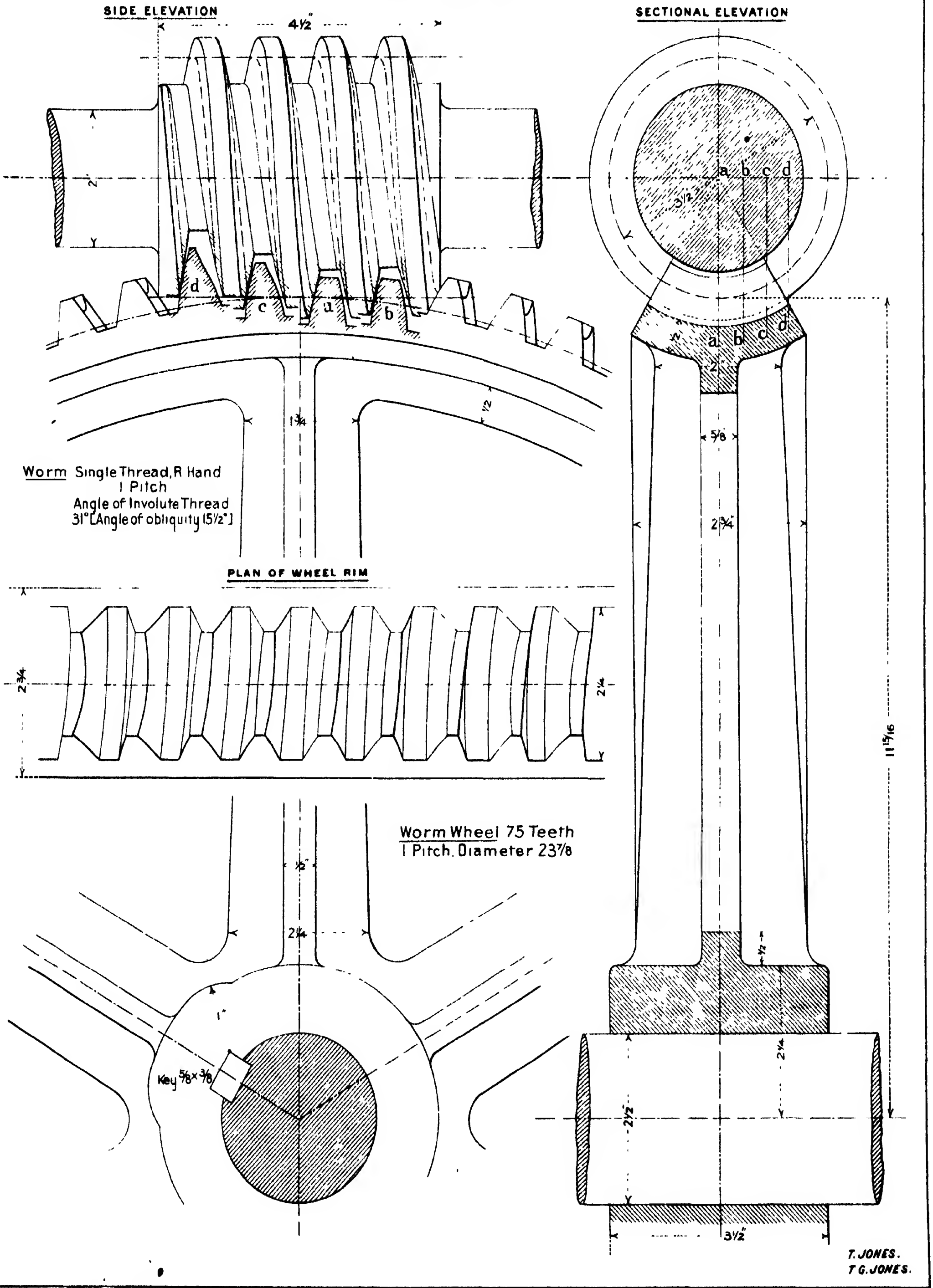


Plate XLVII.—DOUBLE HELICAL SPUR WHEELS.

WHEN two ordinary spur wheels are in gear the point of application of the pressure exerted between a pair of teeth is continually changing. If the profiles of the teeth are formed of cycloidal curves, the path of the point of contact is made up of the portions of the describing circles intercepted between the point circles of the two wheels. (See Fig. 1.)

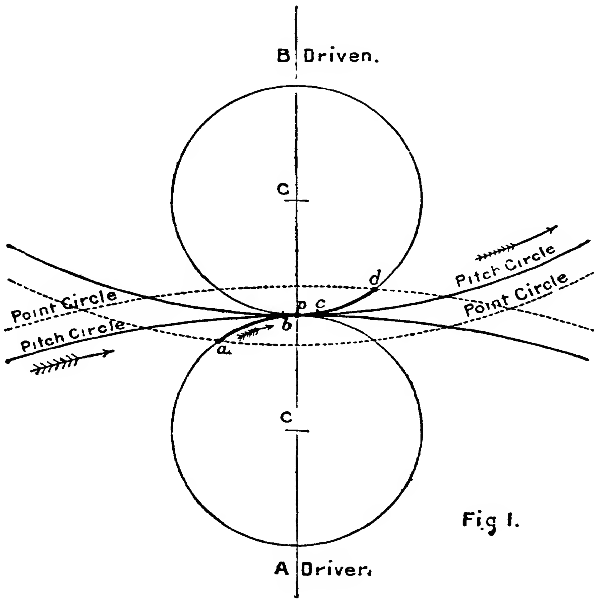


Fig 1.

If **A** is the driving wheel, contact begins at a and ends at d.

Neglecting the deviation of the direction of pressure from the normal to the profiles of the teeth at the point of contact on account of the frictional resistance to sliding, the direction of pressure always passes through the pitch point p. Consequently, it is only when the teeth are passing the centre line that the pressure exerted between them is wholly effective in producing rotation.

The obliquity of action is greatest at the beginning and ending of contact. (The obliquity is usually limited to 30°.)

The continual variation of the direction of pressure is the cause of irregular working of wheels and variable pressure on the bearings, but these objections are entirely removed by the use of accurately machine-moulded helical wheels.

Consider now the action on one another of the teeth of the wheels drawn on Plate XLVII., assuming them first to have ordinary straight teeth of $2\frac{1}{4}$ inches pitch.

Using describing circles of $5\frac{1}{4}$ inches diameter, the length of the path of contact *apd* is about $3\frac{5}{8}''$; so that there will always be two pairs of teeth in gear, whose respective points of contact will be a and c, where a and c are two points on the curve *apd* and $2\frac{1}{4}''$ (equal to the pitch) apart.

The force transmitted from one wheel to the other is the resultant of the two forces acting at a and c, having the directions ap and pc respectively.

If, however, the wheels were divided into a number of narrow ones, and each placed behind the preceding one by a constant amount, the points of contact of the several portions of a pair of teeth would be distributed uniformly along the path of contact: the forces exerted at these points resulting in one more nearly coincident with the tangent through the pitch point p. Also, with such stepped wheels the variation in the direction of the resultant pressure is less than with the ordinary straight teeth. When the slices become indefinitely numerous and narrow the tooth becomes a helical tooth, whose centre line is a helical curve traced on the pitch surface of the wheel.

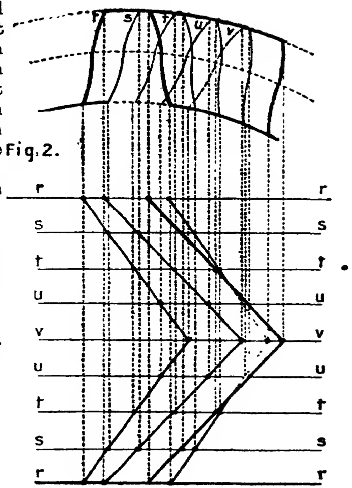


Fig. 2.

To obviate the objection of end pressure on the shafts resulting from the use of single helical wheels, two, having teeth of the same inclination but of opposite directions, are combined to form the double helical wheel.

In the example given the central section of a tooth is $1\frac{1}{2}''$ (*i.e.*, one quarter the width of the wheel) in advance of the ends. Contact between the two pairs of teeth in gear is at the same instant distributed along the arcs ab and cd, which are each equal to $1\frac{1}{2}''$ in length. If the *lead* of the tooth is equal to, or greater than the pitch, the pressure is exerted along the whole length of the arc *apb*, and the obliquity of action is consequently constant and very small.

To obtain the projections of a double helical tooth (see Fig. 2) divide the wheel into n equal parts by section planes at right angles to the axis of the wheel, and for each section plane draw the section of the tooth; *i.e.*, draw between the ends of half a complete tooth $\left(\frac{n}{2} - 1\right)$ equidistant sections. Projecting from the four points of each section into the corresponding section plane, points are obtained on the helical curves of the tooth. NOTE.—The proportions of a tooth are as follows:—

Thickness of tooth on pitch line	0·48 pitch.
Height outside pitch line	0·3 „
Depth below pitch line	0·4 ..

DOUBLE HELICAL SPUR WHEELS.

Scale 4/5 full size